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Production, distribution and utilisation of maize in New Zealand

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Abstract of a dissertation submitted in partial fulfilment of the
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Production, distribution and utilisation of maize in New Zealand

By J.W. Booker

The aim of this study was to document industry information regarding the production, distribution and utilisation of maize in New Zealand's primary and food industries.

Through the case study research approach, twenty seven maize industry specialists from around New Zealand were selected and interviewed, following their identification as key informants. Secondary information was gathered from an extensive document and literature search.

The findings show that there has been a significant upward trend in the area grown for maize silage since its introduction as a forage supplement in the early 1990s. During this same time frame the total production of maize grain has fluctuated between 150,000 tonnes and 200,000 tonnes per annum. Large discrepancies exist between industry sources in regards to industry statistics. The total area in production for the 2008/09 season is estimated to range between 67,200 hectares and 101,600 hectares.

Based on the information uncovered in the research, the 2007/08 and 2008/09 seasons the maize industry grew by 20% each season. This was fuelled by an increasing demand for maize silage in the dairy industry. Supplementary feed usage on dairy farms has increased and maize silage production now accounts for 72% of all maize area planted. The Waikato region is the largest producer of maize, producing nearly half of New Zealand's total maize crop. The dairy industry consumes 99% of the national maize silage production.

In 2008, the livestock feed sector consumed 58% of maize grain production in New Zealand of which most enters the poultry and ruminant sectors. Food and industrial processors consumed the remaining 42%.

Large discrepancies exist between industry sources in regards to industry statistics. The size of the industry may be larger than the Foundation for Arable Research levy accounts for. Potentially there is existing revenue outstanding, which could be invested into industry good initiatives to further the industry.

Key words: Maize, corn, livestock, dairy, grain, qualitative research, production, maize area, supplementary feed, history, farm management.

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Table of contents

Abstract i

Acknowledgments ii

Table of contents iii

List of tables v

List of figures v

Common Abbreviations vi

1. Introduction 1

1.1 Background 1

1.2 Research Objectives 2

1.3 Research Approach 2

1.4 Dissertation Outline 2

2. Methodology 4

2.1 Introduction 4

2.2 Type of Research 4

2.3 Selection of Key Informants 5

2.4 Data Collection 6

2.5 Data Analysis 7

2.6 Confidentiality Issues 7

3. Maize production in New Zealand 9

3.1 Introduction 9
3.1.1 Industry Structure 10

3.1.2 Agronomic Requirements for Maize Growth 10

3.1.3 Yield and Nutritive Value 12

3.2 History of Maize Production in New Zealand 14

3.3 Maize Production and Distribution 17
3.3.1 Total Area 17

3.3.2 Total Production 20

3.3.3 Regional Distribution 21

4. Maize Grain Industry 22

4.1 Livestock Feed 22
4.1.1 Poultry Feed 23

4.1.2 Pig Feed 25

4.1.3 Ruminant Feed 26

4.2 Food and Industrial Uses 27
4.2.1 Dry Processing 27

4.2.2 Wet Processing (Corn starch manufacture) ... 29

4.3 Industry Totals ... 31

4.4 Substitutes for Maize Grain ... 33

4.5 Costs and Returns ... 33

5. Maize Silage Industry ... 35

5.1 Dairy ... 35

5.1.1 Benefits ... 35

5.1.2 Processing and Storage ... 37

5.1.3 Production Systems ... 37

5.1.4 Distribution Channels ... 38

5.2 Beef ... 39

5.3 Substitutes for Maize Silage ... 40

5.4 Costs and Returns ... 41

6. Discussion and Conclusions ... 43

6.1 Review of methodology ... 43

6.2 Price Volatility ... 43

6.3 Supplementary feed usage on dairy farms ... 44

6.4 Economic Contribution ... 45

6.5 Conclusions ... 45

References ... 47

Appendix A ... 52

Appendix B ... 54

Appendix C ... 55

Appendix D ... 57

Appendix E ... 58

Appendix F ... 60

Appendix G ... 61

Appendix H ... 62

Appendix I ... 64

Appendix J ... 65

Appendix K ... 66

Appendix L ... 67

Appendix M ... 68

Appendix N ... 69

List of tables

Table 1: Location and climate summary for potential yield assessment sites (Brown *et al.*, 2007) 11
Table 2: Mean nutritive characteristics of maize silage and maize grain (Kolver, 2000).................................. 13
Table 3: Composition of the kernel of mature dent maize (Chappell, 1985).. 13
Table 4: Area information for land planted in maize in 2006 and 2007... 18
Table 5: Area for 2007/08 derived from the FAR levy revenue: variations dependent on differing seeding rates19
Table 6: Industry growth and maize area estimations for the 2008/09 season 19
Table 7: Total maize grain production the 2007 and 2008 harvests 20
Table 8: Regional distribution (%) of maize land area in New Zealand (Data adapted from Statistics New Zealand, 2008).. 21
Table 9: Total feed usage in New Zealand 2005-2008 (thousands of tonnes/year).. 22
Table 10: Total quantity of manufactured feed entering the ruminant feed sector 26
Table 11: Nutritional Analysis of by-products derived from industrial and food processing of maize 29
Table 12: Nutritional Analysis of by-products derived from industrial and food processing of maize 31
Table 13: End users use of maize grain in 2008 (Constructed from pooled estimates) 32
Table 14: Cereals used in stock feed manufacture for 2006-2008 (Appendix H).. 33
Table 15: Historical gross margin for maize grain grown in the Waikato region (MAF, 2008b) 34
Table 16: Total costs and net profit at different yields and product prices.. 34
Table 17: Extra requirements above maintenance to gain 1 BCS for a dry cow (Macdonald & Roche, 2004)... 36
Table 18: Proportion of maize silage planting by land use in 2008 (results from the contractor survey) 39
Table 19: Historical gross margin for maize silage grown in the Waikato region (MAF, 2008b) 41
Table 20: Gross Margin for traded maize silage for the 2008/09 season given growing costs of $2700/ha........ 42

List of figures

Figure 1: Major end users that operate within the New Zealand Maize Industry.. 10
Figure 2: Crop production potential for varies regions of New Zealand (Adapted from Brown *et al.,* 2007)..... 11
Figure 3: Area and yield of maize grown for grain for the period from 1901 to 1982; yield broken line. (Statistics New Zealand, 1983) 15
Figure 4: Area of maize grown for grain for the period 1980 to 2006 (Data from FAO, 2008).......................... 15
Figure 5: Average yield of maize grown for grain for the period 1961 to 2006 (Data from FAO, 2008) 16
Figure 6: Total annual milk production (million kgMS) from 1991/92 -2007/08 (Data from LIC, 2008) 17
Figure 7: Total imports of Palm kernel extract (PKE) into New Zealand 2004-2008 (Source: NZFMA) 40

Common Abbreviations

- FAR – Foundation of Arable Research
- MAF - Ministry of Agriculture and Forestry
- MJME – Mega joules of metabolisable energy
- ha - hectare
- GDD – Growing degree days
- CRM – Comparative relative maturity
- DM – Dry matter
- kg – kilogram
- t – tonne
- MS –Milksolids
- NZFMA – New Zealand Feed Manufacturers Association
- CSL – Corn steep liquor
- BSC – Body condition score
- PKE – Palm kernel extract

1. Introduction

1.1 Background

The dissertation aimed to understand how much maize is used in New Zealand's primary and food industries, why maize is used and what factors determine its use. This research also aimed to document the present maize situation with respect to production, distribution and utilisation of maize in New Zealand. This research built on and strengthened currently available industry information. Interviews with industry specialists, as well as an extensive literature search were methods used to gather all relevant information needed to achieve the research objectives. This dissertation did not include or focus on the production and utilisation of sweet corn.

Globally, there are two main uses for maize. In developing countries, particularly in tropical and sub-tropical regions, maize is a staple food. In developed countries, such as New Zealand, maize is used primarily as stock feed. Maize is the most commonly grown cereal crop in the world, ahead of wheat and rice production. In the period 2006/07, an average of 784 million tonnes of maize grain was produced annually on 158 million hectares of land (FAOSTAT, 2008). In the same time period, more than 27 countries had over one million hectares sown in maize.

In New Zealand, maize is grown for a number of different end markets. At the producer level the production is split into two categories; maize grain and maize silage. Maize grain crops are produced solely for their grain content, whereas maize silage crops are harvested as whole crops: stem, leaf and cob. Maize grain is a common ingredient in compound feed manufacture and is used in poultry, pork and ruminant feed rations. It is also used in processed food for humans and in industrial processing. Historically, maize in New Zealand has been grown for grain, but the industry dynamics have changed and an increasing amount of maize silage is grown. The largest end user of maize in New Zealand is now the dairy industry.

Maize is intolerant to frost, and grows best in regions with warm soils and high quantities of solar radiation. As a result, maize is successfully grown throughout most of the North Island and in northern regions of the South Island.

There is little published information about the maize industry in New Zealand. However, the Ministry of Agriculture and Forestry (MAF) publish commentary on the industry in their annual Arable Monitoring Report (MAF, 2008a).

1.2 Research Objectives

Based on the research aims, the specific objectives of this study were as follows.

- Identify the key industry stakeholders and their contribution within the New Zealand maize industry.
- Identify the importance of maize for each major stakeholder.
- Document the current scale and production of maize in New Zealand.
- Estimate the economic contribution of the maize industry to New Zealand.

1.3 Research Approach

A qualitative case study approach was chosen for this study consisting of both primary and secondary information. Primary information was sourced through interviews with key informants. Eighteen key industry personnel participated in semi-structured interviews where they were questioned in accordance to their specialisation, and eleven key agricultural contractors participated in a telephone survey. Secondary information was gathered from an extensive document and literature search. Primary and secondary data were collated and presented together in relation to each issue.

1.4 Dissertation Outline

This dissertation has been organised into four chapters that are presented as follows:

Chapter One: Introduction

Chapter Two: Methodology

This section describes the research methods used in obtaining the results, including selection of participants, data collection and data analysis

Chapter Three: Maize production in New Zealand

This section provides a detailed regional breakdown of where maize is grown in New Zealand, and how the industry has existed in history. The chapter presents results from both primary and secondary data.

Chapter Four: The maize grain industry

This section provides information on the maize grain industry, specifically focusing on the major end user markets, market characteristics and costs.

Chapter Five: The maize silage industry

This section provides information on the maize silage industry, specifically focusing on the major end user markets, market characteristics and costs.

Chapter Six: Discussion and Conclusions

This section discusses the main findings identified in Chapter Three, Four and Five. An explanation of all limitations and problems is found in this chapter.

2. Methodology

2.1 Introduction

The objective of this study was to highlight and document all key aspects of the present maize industry, focusing on the industry sectors involved and the area in production. A case study approach was chosen, consisting of semi-structured interviews with eighteen key industry participants. In addition to the interviews, eleven agricultural contractors throughout the country were surveyed by telephone. The interviews were completed throughout Auckland, Waikato, Gisborne, Manawatu and Canterbury regions of New Zealand from November 2008 to January 2009.

This chapter describes the methodology applied for data gathering, organisation and analysis, and explains why a qualitative approach was used.

2.2 Type of Research

A qualitative approach was adopted to provide insights, facts, trends and a greater understanding of issues surrounding the maize industry. Patton (1987, p.44) states that "qualitative methods are particularly oriented toward exploration, discovery and inductive logic". Yin (1994, p.34) stated that evidence for case studies can be obtained from "six distinct sources: archival records, documentation, direct observation, participant observation and physical artefacts and interviews".

Qualitative frameworks are appropriate where the purpose is to seek insights and understandings that will address specific research questions, but where there are no specific hypotheses to be tested. The data collected within qualitative frameworks can include numeric data. The decision to use a qualitative structure to support this research was logical after first identifying the overall purpose behind the study. Not only was the research aimed at documenting facts and trends that exist, the in-depth requirement of the research warranted the use of semi-structured interviews as a mechanism for probing and finding new ideas. Quantitative methods (i.e. numeric hypotheses testing) would have limited the scope of the study, limiting the researcher's ability to create discussion, and thus search for unforeseen issues to be investigated further. The personal approach of a semi-structured interview allowed the interviewee to talk freely and allowed the interviewer to capture the points of view without pre-determining boundaries through set questions. Verwoerd (2007) also suggests that this technique will encourage truthful and more complete thoughtful answers to questions. The case study method will hopefully give this study validity in the arable sector as it is based on the knowledge of experienced informants.

Alongside the interviews, a small telephone survey was constructed and issued to eleven agricultural contractors throughout the country. The survey consisted of a number of discrete and open-ended questions. The research strategy was aligned with the scale and the budget of the research project.

2.3 Selection of Key Informants

The nature of this research required the identification of key participants with involvement in specific areas of the maize industry to become informants for the study. The Foundation for Arable Research (FAR) is a key partner of this research project. FAR is an applied research organisation responsible to New Zealand arable growers and involved in funding of arable research and technology transfer. FAR was formed in 1995 and operates under the Commodity Levy Legislation. The researcher worked in conjunction with FAR in order to develop a list of key persons that would be suitable participants. FAR has formed well established working relationships with many of the firms that operate within the maize industry. The criteria for selection were based on two essential factors: experience and position in the industry. FAR is in regular contact with agricultural contractors, many of whom are on the maize research committee. A list of suitable contractors was supplied by FAR.

The number of case study participants was limited by time and budget constraints. The list of key informants included:

- three specialists in dairy farm systems and research,
- four representatives from the stock feed industry,

- four representatives from seed and product sales companies,
- three grain merchants,
- two representatives from beef finishing feedlot operations and,
- two representatives from the food processing sector.

A wide range of participants were chosen due to the likelihood that between them they would possess all the information required. All significant industry sectors were covered by at least one specialist representative. FAR were also key participants, supplying the collected levy information.

2.4 Data Collection

All participants were initially contacted by FAR and were informed of the study and that the researcher would be in contact within 3 to 4 days. This was followed up by a phone call or an email within this 3 to 4 day period. A mutually suitable time was arranged for the meeting. In most cases the researcher met at the participant's place of work, or a neutral venue that was suitable. Interviews lasted between one and two hours. In the case that a participant was unable to meet the researcher in person, a time was arranged for the interview to take place over the phone. Two interviews were conducted by telephone; the remainder were conducted in person.

The interview strategy used to collect data for the purposes of this research revolved around having a small number of pre-determined questions (Appendix A). These questions explored the key topics relating to the participants area of expertise. The interview guide provided a degree of structure to the interview. In addition, the interview had adequate flexibility to allow the interviewer to shift the focus of the interview to areas of new importance.

Interviews were recorded in full on audio tapes and also hand recorded in note form to ensure accuracy in the data collection process. Confidentiality was assured, and participants were asked if they objected to the recording of the conversation. The audio recordings were analysed by the researcher and any further notes were written. In the case that any information was missing, a note was made and the interviewee was later contacted and questioned via email. Any reference or resource material provided by the interviewee was documented, and if relevant, the data obtained was included as results.

Alongside the interviews, agricultural contractors were sent a survey by email and were later contacted by phone to discuss the questions (Appendix B). The contractors were not interviewed in person. In some cases email addresses were unable to be obtained so the survey objectives were discussed by phone. Contractors either verbally communicated their answers or emailed through their responses.

2.5 Data Analysis

"Triangulation refers to using different research methods to hone in on an event from two or three different angles (Davidson & Tollich 1999, p.34)." The process of triangulation was used to analyse data collected in this study. Data were gathered in a number of different forms and was then compared to ensure no major discrepancies existed. This process ensured the researcher could have greater confidence that the findings were valid. The FAR arable levy, the data received from the interviews, along with any other reference or resource material was compared to ensure validity was maintained. Validity is confirmed when consistent information is obtained without large discrepancies.

After the data collection process, case study notes were evaluated and allocated according to their section of relevance. Information gathered was matched against the key research questions. Industry sectors formed the headings of the results and the discussion. Any information collected that was not aligned to the research objectives was deemed irrelevant and excluded from the results section.

Survey results from the agricultural contractors were recorded on an excel spreadsheet and summarised.

2.6 Confidentiality Issues

Every effort has been made to protect the confidentiality of the participants involved. The audio recordings and notes were stored in a location only accessible to the researcher. Every effort has been made to prevent the readers of this report being able to identify the participants and their respective firms. The researcher does acknowledge that these confidentiality efforts may become void in circumstances where the reader had a close acquaintance with a particular firm, especially as major firms dominate the market in some areas. Received emails and resource information was only assessable through a secure login process in which a password is required.

3. Maize production in New Zealand

3.1 Introduction

Maize is a cereal grain plant, also commonly known as corn. Maize has physiological characteristics that allow it to efficiently assimilate carbon dioxide. As a C4-pathway plant, maize requires warmer temperatures than common pastures species in New Zealand. However, under favourable climatic conditions crop yields are significantly higher than alternative cereals and pasture grasses (Brown *et al*., 2007).

The annual plant is grown for a wide range of end uses. In many developing countries, maize is the primary source of carbohydrates in human diets. In developed countries, maize is generally grown for its use as a high energy stock feed. The versatility of maize in its uses as grain, green feed and silage gives it a significant advantage over other crops.

There are a number of key companies and industry participants that provide the services and resources that support the maize industry in New Zealand. The key seed companies are locally owned, and the majority of the seed is grown locally. The Foundation for Arable Research (FAR) is the industry body for the arable sector. FAR collects a levy on the sales of maize seed (FAR, 2008a). Revenue is then invested in research for the further development of the industry. Agricultural contractors are pivotal participants in the industry, generally responsible for the management of planting and harvesting of crops. Most large contractors are also traders of maize. A strong support network of services, infrastructure and expertise exists, buoyed by New Zealand's pastoral agricultural sectors.

Most previous research on the New Zealand maize industry dates back to the 1980s (Lough, 1984; Hughes & Sheppard, 1985; Eagles & Wratt, 1985). During this time the maize industry was based on maize grain production. It was not until the 1990s that maize silage became a significant part of the industry. In 2000, MAF included a maize model as part of the Arable Monitoring Report and since this time there has been commentary by MAF on movements within the industry. Seed sales are confidential, and therefore accurate maize area statistics are difficult to obtain. The Agricultural Production Census which is carried out by Statistics New Zealand once every five years contains maize area and production information. The most recent census was based on the 2006/07 production season.

3.1.1 Industry Structure

The New Zealand maize industry can be categorised into two sub-industries; maize silage and maize grain (Figure 1). Although the agronomic growing practices are similar, processing and end user dynamics differ significantly between the two crops. There is a small amount of cross over that exists between maize grain and maize silage crops. Most of the maize hybrids planted in New Zealand are dual purpose, meaning they can be grown for silage or for grain. The area planted in maize silage and maize grain may then differ from the area harvested depending on market and climatic conditions.

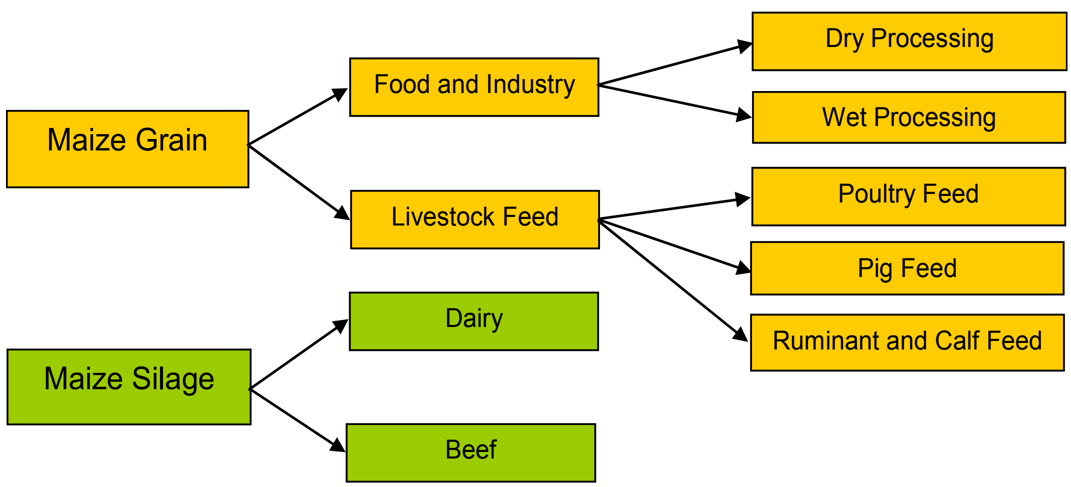

Figure 1: Major end users that operate within the New Zealand Maize Industry

3.1.2 Agronomic Requirements for Maize Growth

Maize is a C4 plant and given optimal conditions has very high growth rates. Maize is very sensitive to frosts and as a result is planted in the spring when the risk of frosts has subsided. Maize requires 120-180 frost free days to produce a silage crop (Moot *et al.*, 2007). Temperature and radiation are key factors that determine the potential production of maize. Maize should not be planted in the spring until the soil temperature is above 10°C. This usually occurs around mid October in the Northern regions of New Zealand, but often not until early November in the South Island. Maize has a base temperature range from 8-10°C. The base temperature is the minimum temperature a plant requires before it can effectively assimilate carbon dioxide through the process of photosynthesis.

Brown *et al.* (2007) modelled potential maize yields based on historical data from various regions (Table 1) throughout New Zealand. Crop potential yields are the highest in Whakatane where total radiation is the highest at 15MJ/m², there is limited risk of out-of-season frosts and the average annual temperature is a mild 14°C (Figure 2). In contrast, the potential yield of maize crops in Southland is restricted by low levels of radiation, a high risk of out-of-season frosts and cooler mean temperatures. The frost risks are heavily reduced in eastern coastal areas, allowing crops to be planted earlier in the spring. For example, there is little risk of frost in Whakatane after the 1st of September.

Table 1: Location and climate summary for potential yield assessment sites (Brown *et al.*, 2007)

			Annual means		Frost-Free	
Site	Latitude (°S)	Altitude (masl)	Temp °C	Radiation (MJ/m²)	Start Date	Finish Date
Ruakura	37.4	11	13.6	13.7	5 Sep	9 May
Whakatane	37.9	7	14.0	15.4	1 Sep	26 May
Lincoln	43.4	11	11.5	13.3	14 Oct	14 Apr
Gore	46.1	123	9.7	12.3	5 Oct	13 Apr

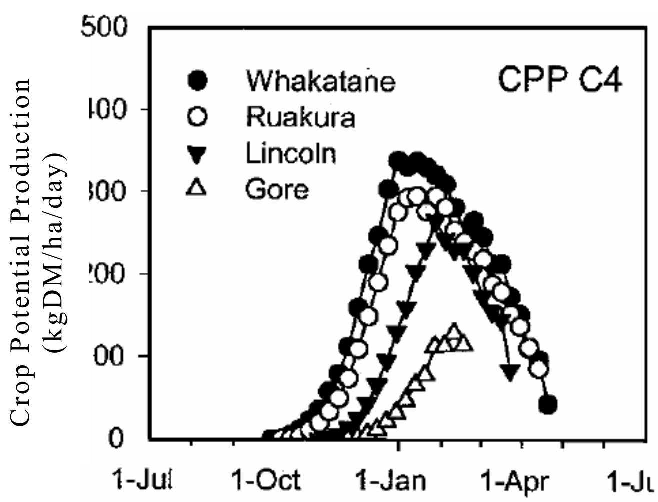

Figure 2: Crop production potential for various regions of New Zealand (Adapted from Brown *et al.*, 2007)

Maize crops mature according to the accumulation of thermal time units (Growing Degree Days, GDD). The relative maturity rate of maize hybrids is usually reported as CRM (comparative relative maturity) by seed companies. Longer CRM hybrids have higher dry matter yield potential but require more heat to reach harvest maturity than short CRM hybrids (Densely *et al.*, 2004).

In the Waikato region, maize silage hybrids with a CRM from 87-107 are recommended whereas in Canterbury the recommendation is 78-82 CRM (Moot *et al.*, 2007). As Canterbury has lower average temperatures than the Waikato region, a maize crop will require a longer length of time to mature. The higher CRM hybrids used in the Waikato will be ready to harvest in 125-156 days, whereas the hybrids used in Canterbury will still need 155-172 days to harvest (Genetic Technologies Ltd, 2005). The planting populations are lower in crops planted for maize grain compared with silage. The average planting population for maize grain is 90,000 seeds per hectare, in comparison with 104,000 seeds per hectare for silage (Genetic Technologies, 2008). Since this information has been derived from the recommended planting rates suggested by seed company Genetic Technologies Ltd, there could be discrepancies between recommended rates and actual planted rates.

3.1.3 Yield and Nutritive Value

Maize silage yields are usually in the range 16.0-25.0 t DM/ha. The highest yields in New Zealand are found in the northern regions of the North Island, notably Northland, Bay Of Plenty and Waikato. Yields of 16-20 t DM/ha have been reported in the South Island by Wilson *et al.* (1994), but the risk of crop failure is much higher in the cooler environments. Between 1930 and 2000, maize silage dry matter yield has increased at an average rate of 146 kg DM/ha/yr (Lauer *et al.,* 2001). Deane (1999) reported that there was a three-fold increase in maize silage yields between 1958 and 1998.

Kolver (2000) suggested that maize silage has an average crop metabolisable energy of 10.6MJ/kgDM (Table 2). Millner (2002) found that this ranged from 10.3 to 11.3MJ/kg DM with significant differences among hybrids. Hybrids with a high ‘grain to stover ratio’ are considered important for forage nutritive value because of the high digestibility of grain, consisting of around 70 percent starch (Milner, 2005). The grain proportion of the plant contributes 80 percent more energy then the stover (stem and leaf) on a wet weight basis (Densely *et al.,* 2004). Therefore to obtain maximum quality silage, cobs must be allowed to fully mature. Targets for maize harvested for silage are approximately 45 percent grain (12.6-12.9 MJ ME/kgDM), 18 percent cob (9.6-11.2 ME), 11 percent leaf (9.4-9.8 ME), 25 percent stem (7.6-8.7 ME) and overall dry matter percentage of approximately 34 percent (Millner *et al*., 2005). Starch is the main source of energy in maize. Starch is a highly fermentable form of carbohydrate which is readily digested in the rumen.

Table 2: Mean nutritive characteristics of maize silage and maize grain (Kolver, 2000)

	Dry Matter (%DM)	ADF (%DM)	NDF (%DM)	Crude Protein (%DM)	ME(MJ ME/kgDM)
Maize Silage	34.5	25.7	43.7	7.8	10.6
Maize Grain	89.0	10.8	13.9	10.4	13.6

Grain yields from New Zealand grown maize crops typically average 10.5t/ha (Reid *et al*., 2006). Actual yields range from 8.5 – 19.4 t/ha. The highest yields are obtained in eastern regions with Gisborne and Hawke’s Bay obtaining higher average yields in comparison with other grain growing regions, largely due to the higher sunshine hours on offer. Most of the hybrids available in New Zealand are dual purpose, meaning they can be harvested for grain or for silage depending on the growing conditions.

The three components of the grain of interest to the processor are the endosperm, the germ and the pericarp (Table 3). The endosperm is the principal source of starch, a rich source of carbohydrate. The germ is the principal source of fat and is the key ingredient for oil extraction. “The protein which is more uniformly distributed throughout the kernel, is an important ingredient in animal feed” (Chappell, 1985, p.9).

Table 3: Composition of the kernel of mature dent maize (Chappell, 1985)

	Dry Weight (%) As % of Whole Kernal	Starch (%DM)	Fat (%DM)	Protein (%DM)	Fibre (% DM)
Endosperm	83	86	1	9	4
Germ	11	7	35	18	40
Pericarp	6	7	1	4	88
Whole kernel	100	73	5	10	12

3.2 History of Maize Production in New Zealand

The earliest recorded introduction of maize into New Zealand was in 1772, during one of Marion de Fresne's voyages (Rhodes & Eagles, 1984). By the middle of the nineteenth century maize was an integral part of Maori agriculture in New Zealand. "According to historical accounts, Maori ate maize in raw form and carried dry grains when travelling" (Bansal & Eagles, 1985 p.3). Maize was one of the few vegetable crops introduced by the early Europeans that Maori incorporated into their culture. It was traditionally grown as a summer crop in the Maori gardens. It is difficult to estimate the area in production during the nineteenth century, but most of the early maize was grown in the top half of the North Island, with little to no plantings in the South Island (Rhodes & Eagles, 1984).

Between 1900 and 1960, the maize crop in New Zealand ranged between 2000 and 5000 hectares (Bansal & Eagles, 1985), most of which was grown for grain. Open pollinated varieties were grown until the 1940s but were steadily replaced by imported hybrids that were better suited for modern agriculture. Predominantly from the United States, imported hybrids changed the dynamics of the maize industry. The greater yielding ability of the imported maize genetics increased the viability of maize production, thus cropping farmers responded by increasing planting areas. Until the 1960s, maize was primarily grown in the warm eastern regions of Hawke's Bay, Poverty Bay and Bay of Plenty. During the 1970s, the Waikato/Bay of Plenty region established itself as the largest maize production area in the country.

Both the average yield and the area of maize grain crops in New Zealand rapidly increased over a short space of time during the 1960s through to the mid 1970s (Figure 3). Between 1950 and 1970, there were advances in maize crop agronomic practices, through improved weed, pest and disease management. Through improved yielding hybrids and improved agronomic management, maize grew in popularity. The area of maize harvested for grain increased from less than 5,000 hectares in 1966 to 29,000 hectares in 1976 (Eagles *et al.*, 1985). It then declined to 20,000 hectares in 1980, and has fluctuated around that level until the most recent data was collected in 2007 (FAO, 2008) (Appendix C).

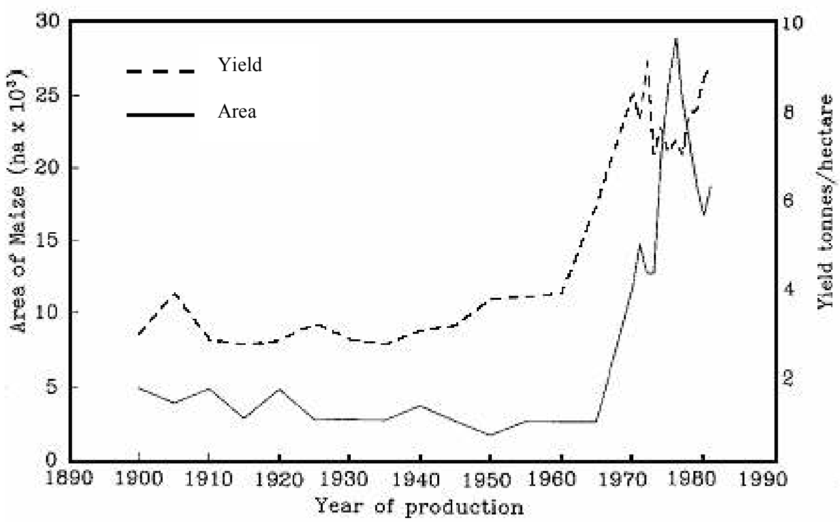

Figure 3: Area and yield of maize grown for grain for the period from 1901 to 1982; yield broken line. (Statistics New Zealand, 1983)

The area grown for maize grain has fluctuated between approximately 14,000 and 20,000 in the past two and a half decades but there is no overall trend. The average area planted over that time frame is 17,500 hectares (Figure 4).

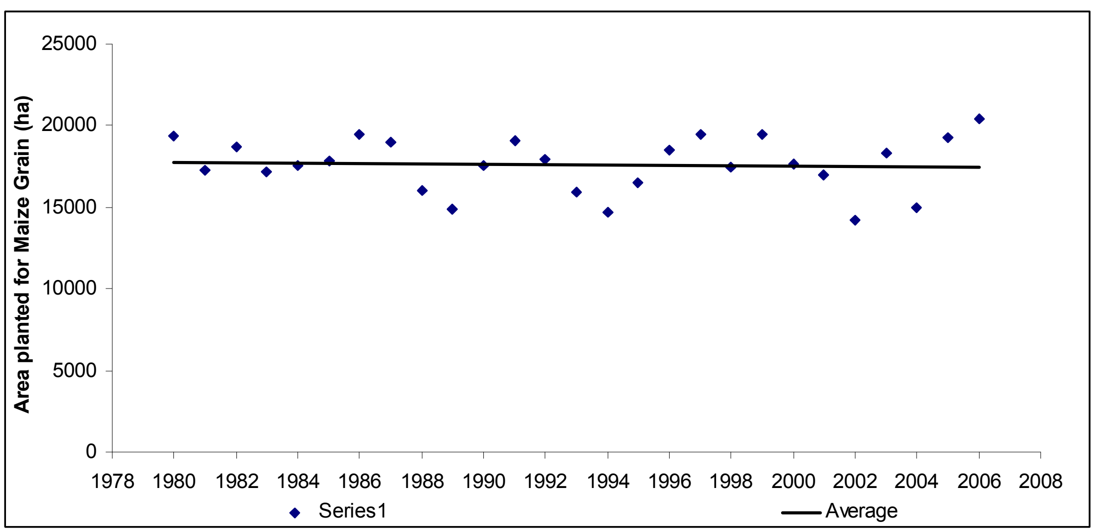

Figure 4: Area of maize grown for grain for the period 1980 to 2006 (Data from FAO, 2008)

Although the area in production of maize grain shows no trend since 1979, the total production has increased due to advances in crop yield (Figure 5). Improvement in crop traits including stress tolerance throughout the 1980s and the early 1990s helped removed the volatility seen in crop yields from season to season.

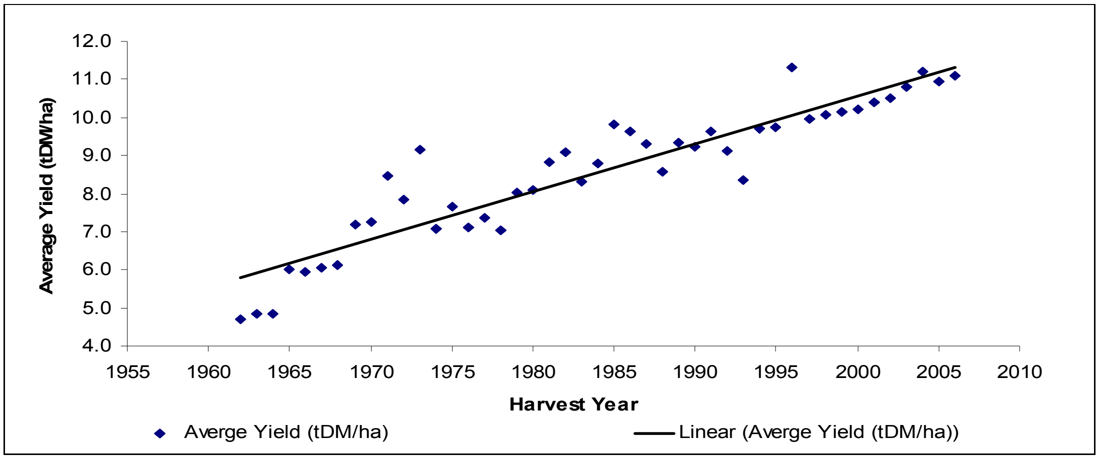

Figure 5: Average yield of maize grown for grain for the period 1961 to 2006 (Data from FAO, 2008)

Growing maize silage as a supplement for dairy cows is a relatively new practice in New Zealand. MAF first published a report on maize silage in the Farm Monitoring Report in 2000. At the time it was estimated that 12,000ha of maize silage was grown nationally. The publication states 'the total area in maize silage is very difficult to gauge due to the number of small growers and the commercial sensitivity surrounding seed and input sales' (MAF, 2000). The first maize silage crops were concentrated around the Waikato and Bay of Plenty regions.

As pasture growth is the key limiting factor for milk production, farmers have increased their use of supplementary feeds in order to balance pasture deficits at specific times of the season. Kolver *et al.* (2001) showed that growth in the amount of maize silage consumed by the average dairy cow was strongly related to growth in the dairy industry. In the 1991/92 season the New Zealand dairy industry produced a total of 637 million kilograms of milksolids (kgMS). This total production has doubled in the 15 years since then with the country producing 1,270 million kgMS in the 2007/08 season (Figure 6).

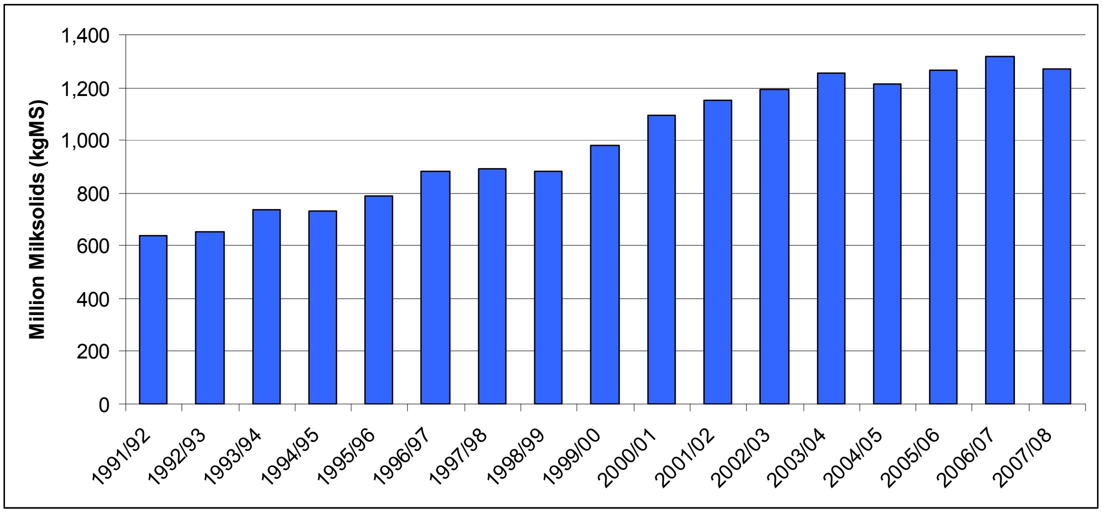

Figure 6: Total annual milk production (million kgMS) from 1991/92 -2007/08 (Data from LIC, 2008)

3.3 Maize Production and Distribution

3.3.1 Total Area

A number of different sources of information were collected and used to estimate the total area of maize planted in New Zealand. Area information was obtained for both the 2006 and 2007 planting seasons. The FAR data was derived from the revenue collected from the maize seed sales levy. The chemical company's data was established through extensive analysis of maize herbicide sales and market share information. The national feed assessment data was compiled by MAF where analysts contacted a number of specialists in the maize industry. Information was also sourced from Statistics New Zealand.

Dating back to the 2006/07 season, total maize was stated as 49,500ha by Statistics New Zealand's Agricultural Production Census 2007. The estimates of the national maize crop for the 2006/07 season ranged from 49,500ha to 60,000ha (Table 4).

Area information obtained from the revenue from the FAR levy for the 2007/08 season is the most complete information available; however, the results do not correspond with other sources. The FAR levy of \$0.90 per 10,000 seeds equates to \$7.20/ha worth of costs for an average maize grain crop (80,000 seeds/ha) and \$9.72 for an average maize silage crop (108,000 seeds/ha). The levy information obtained by FAR did not differentiate between maize silage and maize grain. Total revenue obtained for the 2007/08 season was $500,000. Given the assumption that the maize grain area for the 2007/08 season was 17,700ha, the total maize silage area was then derived to be 38,277ha, making the total area just under 56,000ha (Appendix D).

Information obtained from a key chemical company suggested the total area in maize production was significantly higher in 2007/08 than the FAR data at 83,000ha. The chemical, acetachlor is the herbicide (pre-emergent) commonly applied to all maize crops at a rate between 2.5-3L/ha. A spokesman from the chemical industry suggested the average application rate is 2.9L/ha. Every year that particular chemical company matches the amount of acetachlor product sold along with information regarding the company's position in the market in order to work out the size of the industry. Another source of information, the national feed assessment report suggested a total industry area for the 2007/08 season of between 60,000ha to 70,000ha could be conservative. The estimates of the national maize crop for 2007/08 season therefore ranged from 56,000ha to 83,000ha (Table 4).

Table 4: Area information for land planted in maize in 2006 and 2007

Source	Year Planted	Maize silage (ha)	Maize grain (ha)	Total (ha)
Statistics NZ[1]	2006	32,459	17,030	49,489
Chemical company[2]	2006	40,500	19,500	60,000
Statistics NZ	2007	-	18,500	-
Chemical company	2007	62,000	21,000	83,000
FAR[3]	2007	38,277	17700	55,977
National Feed Assessment	2007	52,300	17700	70,000

[1] Agricultural Production Census 2007 (Statistics New Zealand, 2008)
[2] Company confidential
[3] Area derived through a series of assumptions including seeding rates and maize grain area.

The two key assumptions used to derive the total area using the FAR data were the planting population rate and the area of maize grain. Variation in the planting population did not significantly change the overall result (Table 5) which suggested that the area derived was significantly less than other sources stated.

Table 5: Area for 2007/08 season derived from the FAR levy revenue: A sensitivity of area estimates based on four different seeding rate scenarios

	Seed Rate Scenarios			
Seeds/ha - Maize Grain	80,000	85,000	90,000	90,000
Seeds/ha - Maize Silage	100,000	95,000	104,000	108,000
Estimated Maize Grain	17,700	17,700	17,700	17,700
Total Area	59,000	60,300	55,750	55,000

Information about industry growth was obtained for the 2008/09 season (Table 6). Industry sources, both product sales representatives and agricultural contractors suggested the industry has grown at over 20% for the past two seasons. If the Agricultural Production Census information gathered by Statistics New Zealand was accurate, the size of the industry would be at least 71,000ha for the 2008/09 but other sources suggest the actual market size may be over 100,000ha. Growth in the maize grain area was said to be unchanged by many, however, increases of up to 15 percent were noted by some respondents. All respondents suggested that total industry growth was at least 20 percent. Therefore the total maize area in 2008/09 is likely to be within the range of 67,200ha to 101,600ha.

Table 6: Industry growth and maize area estimations for the 2008/09 season

	Maize silage (ha)	Maize grain (ha)	
Contractor Survey	20%	0-5%	
Industry Personnel	20-30%	0-15%	
Area in 2008	Maize silage (ha)	Maize grain (ha)	Total Area (ha)
Low	49,500	17,700	67,200
High	80,600	21,000	101,600

The research identified that large discrepancies exist between industry sources in relation to the total area planted in maize, illustrating the lack of accurate information that exists in the maize industry. As the market for seed sales is dominated by one large company, it is likely that the company would have an accurate understanding of the size of the New Zealand maize market. The confidential nature of such information prohibited the study from obtaining such information from the seed companies. The levy information obtained for the 2007/08 season was the first full seasons worth of collections. The 2008/09 seasons revenue was not able to be obtained for use in this study. Once several years of revenue are accurately collected more detailed information on industry trends will be available.

3.3.2 Total Production

Maize Grain

A range of maize grain production information was obtained from a range of industry sources. Total maize grain production for the 2007/08 season ranged between 165,000 and 210,000 (Table 7). According to the country's key grain merchants, New Zealand's production of maize grain typically ranges from 160,000 tonnes to 180,000 tonnes. Grain yields were typically reduced as a result of the drier than usual conditions in 2007/08. Average grain yields are expected to be at least 20 percent higher in 2008/09, so it is likely total grain production will be over 200,000 tonnes.

Table 7: Total maize grain production the 2007 and 2008 harvests

	2006/07 estimate	2007/08 estimate
MAF¨	160,000	165,000
Statistics NZ	182,836	210,400
National Feed Assessment	-	185,600

¨ (MAF, 2008b)

Maize silage

Over the past four seasons, average yields for maize silage have ranged between 17.5tDM/ha and 21.0tDM/ha (MAF, 2008a). The national feed assessment report suggests total production of maize silage increased significantly, from 690,000 tonne in 2006/07 to 920,000 tonne in 2007/08. Increases in total production align with increases in area. Average yields for the 2008/09 season are likely to be over 20tDM/ha. Total production is then likely to range between 920,000 and 1,600,000tDM based on the estimated area range for maize silage.

A historical survey of maize contractors found that about half of their farmer clients were growing maize silage in the same paddock annually (often on a run-off) and the other half chose a poor or problem paddock that needs regrassing (Densely *et al.*, 2005). Similar results were established from the contractor survey in this study. The researcher found that of the 18,500ha planted by the surveyed contractors 51 percent of all maize planted was in land out of long term pasture. Rates of continuous cropping varied between contractors. Contractors specialising in maize grain tended to have less maize crops planted in paddocks that were previously in long term pasture.

3.3.3 Regional Distribution

The most recent information detailing the regional distribution of maize in New Zealand has been derived from the latest New Zealand Agricultural Production Census (Table 8) (Statistics New Zealand, 2008). The census shows that nearly half of the maize silage is grown in the Waikato region and approximately 90 percent of the maize silage is grown in the North Island. The Waikato region is also the largest grain growing region, followed by the Bay of Plenty and Gisborne regions. There are regions that generally only produce one of the two maize crops. In Taranaki and Canterbury, maize grain crops are uncommon while in Gisborne only a small proportion of maize silage is grown.

Table 8: Regional distribution (%) of maize land area in New Zealand (Data adapted from Statistics New Zealand, 2008)

	% of Maize Silage	% of Maize Grain	% of Total
Northland	7.8%	3.2%	6.2%
Auckland	2.9%	7.1%	4.4%
Bay of Plenty	6.4%	18.4%	10.5%
Waikato	48.1%	32.4%	42.7%
Taranaki	7.0%	C	4.6%
Gisborne	0.5%	15.6%	5.7%
Hawke's Bay	2.6%	7.6%	4.3%
Manawatu	10.5%	11.9%	11.0%
Wellington	2.8%	C	1.8%
Total North Island	**88.7%**	**97.2%**	**91.6%**
Marlborough	0.4%	C	0.2%
Tasman	1.0%	C	0.6%
Canterbury	9.0%	2.5%	6.8%
Otago	0.4%	C	0.3%
Southland	0.6%	0.0%	0.4%
Total South Island	**11.3%**	**2.8%**	**8.4%**
C = confidential			

4. Maize Grain Industry

Maize grain is primarily used to meet the domestic requirements of compound feed production, corn starch manufacture and food processing.

4.1 Livestock Feed

Maize is an important grain in the compound feed industry in New Zealand. It is a key source of feed for poultry, pork and ruminant producers. However, due to the difficulty in successfully growing maize grain in the South Island (due to the shorter growing seasons) and the costs of transport from the North Island, maize grain is primarily used in the North Island. Maize, wheat and barley are typically interchangeable in compound feed production with usage depending on price and availability. Grains and grain by-products account for 67% of all ingredients in compound feed manufacture in New Zealand while animal and plant proteins account for 25%.

Poultry feed is the largest consumer of compound feed in New Zealand, consuming 58% (4 year average) of all feed used in compound feed (Table 9). The figures show that the quantity of feed used in both the pork and poultry industries each year is consistent, with no trend of significant growth or decline. There has, however, been an increase in the total feed used by New Zealand's livestock industries in the last three years, owing to a growing ruminant feed sector. Feed sector groups unlisted include poultry breeders, horse and other minor animal feed types (Appendix E)

Table 9: Total feed usage in New Zealand 2005-2008 (thousands of tonnes/year)

Industry	**2005**	**2006**	**2007**	**2008**
Poultry (growers)	357	343	336	349
Poultry (layers)	126	112	117	127
Pigs (growers)	160	144	144	142
Pigs (breeders)	58	43	43	40
Ruminant (incl. calf)	87	118	161	216
Other	62	69	76	91
Total	850	829	877	965

Source: (NZFMA, 2006; NZFMA, 2006; NZFMA, 2008; NZFMA, 2009)

The proportion of maize grain included in livestock feed production has typically decreased over the last 25 years. In 2008 maize grain accounted for 13% of all grains used in stock feed manufactured in New Zealand whereas maize grain accounted for 32% of total feed used in 1983 (Hughes & Sheppard, 1985). During this time the stock feed industry has grown from a total of 304,000 tonnes to 877,000 tonnes.

Although the New Zealand Feed Manufacturer's Association (NZFMA) statistics are helpful in determining the total amount of feed used total by each industry sector, there are limitations. First, there is no record of the quantities of maize grain that are used for each industry sector. Second, there are industry participants that are not associated with the NZFMA. This may include growers that sell directly to the end users. Feed manufacturers are not obligated to be apart of NZFMA. It is unknown what proportion of stock feed millers are members of the NZFMA. At least one major stock feed miller in the Waikato was identified as a non-member.

4.1.1 Poultry Feed

Industry Structure

The poultry industry is split into three industry sectors: poultry meat growers, poultry meat breeders, and layers. Imports of fresh and frozen poultry meat into New Zealand are restricted, thus the majority of New Zealand's poultry production is domestically produced. Poultry production includes chickens, turkey and duck. There are three large poultry meat producers. Between them they supply approximately 98 percent of the New Zealand market. The larger players in the poultry industry own vertically integrated subsidiary feed milling companies, and given their scale they can often cost effectively import cheaper substitute grains. According to the NZFMA's compound feed statistics for the year ending 31 December 2008, the three poultry sectors combined consumed just over 528,000 tonnes or 54 percent of the total compound feed produced (NZFMA, 2009). Best estimates of maize grain usage and specific reasons why maize grain may be used were obtained by industry specialists.

Maize Grain Usage in Layer Feed

Maize grain is commonly used in North Island layer diets instead of other price competitive products for two main reasons. Firstly, maize contains high levels of carotene, the natural yellow pigment, used to colour the yolks in eggs. Diets without significant proportions of carotene need additives such as the synthetic product called astazthanthium, or ground marigold flowers imported from China. Secondly, domestic grains are preferred as imported grains are required to undergo processing or treatment. MAF protocol requires imported grains to be ground to 300 microns, thus affecting the grains ability to flow through the layer sheds. The total quantity of maize grain entering the poultry industry as layer feed was estimated by the grain procurement manager of a major stock feed company to be between 30,000-35,000 tonne. This equates to around one quarter of all feed used in poultry layer production.

Maize Grain Usage in Poultry Meat Feed

Wheat is the main source of grain used in poultry meat (broiler) diets. However, moderate amounts of barley and maize grain are commonly used. The larger producers tend to use proportionally less maize than the smaller producers. One broiler producer uses maize grain as the sole cereal ingredient in feed rations, suggesting that 'cost of transport' is a factor deterring the use of imported feed. Depending on the proximity to major ports, imported alternatives are often more cost effective depending on the market environment. According to several specialists in the poultry industry, the proportion of maize grain in grower diets has steadily decreased over the last 10 years. Most growth in grain usage in the poultry meat sector can be attributed to the increased importation of substitutes to maize grain, particularly wheat and sorghum. A specialist in grain procurement estimated that the total quantity of maize grain used in broiler feed is approximately 15,000 tonnes. A company representative in a similar role suggested that this quantity is likely to be closer to 20,000 tonne. Using the higher figure, maize grain accounts for approximately 6% of all feed used in poultry meat diets.

The total volume of maize grain entering the poultry industry for the 2007/08 year is therefore said to range from 45,000 to 55,000 tonne.

4.1.2 Pig Feed

Industry Structure

Maize grain is a common ingredient used in pig diets alongside wheat and barley. It is, however, only used in the North Island, due to its relative availability compared to other grains. Maize use is more common in the Waikato and Bay of Plenty region as piggeries are in close proximity to the key maize growing areas. Cartage costs of alternative grains are higher in these regions as regional wheat and barley crops are rare.

Unlike the poultry industry, the pork industry is not buffered from import barriers, and large amounts of pig meat products are imported into New Zealand. Domestic pig meat producers are therefore competing against overseas producers.

For the 2008 year, the NZFMA show the pork industry using a total of 182,100 tonnes of feed in compound feed production, of which 40 percent of feed was consumed in the North Island and 60% in the South Island (NZFMA, 2009). Pig growing operations consume 77 percent of the total feed, while pig breeding operations consume the remaining 23 percent of feed.

Maize is typically purchased via the spot market, at a time that suits the pig operation. There are, however, still a number of grower-merchant contracts that exist. Maize does have a cost advantage over barley and wheat given it is harvested three to four months later, reducing the cost of grain storage for some parts of the year. The price of maize grain relative to substitute products is the biggest factor determining its use in the pork industry.

Maize Usage in Pig Feeds

Maize grain is a commonly used feed in North Island piggeries. In terms of the comparative nutritional quality of the grains, the main factors to be considered for production are energy content and protein or amino acid levels. While maize grain is a relatively high source of digestible energy, it is lower than barley and wheat in lysine and tryptophan, two essential amino acids for pig production. A stock feed industry representative suggested that domestic grains are preferred in the pork industry as processed imported grains often cause ulcerations in growing pigs. Thus, maize grain is preferred alongside domestically produced barley and wheat.

A pork industry representative estimated that cereals make up approximately 80 percent of the ingredients in pig feed and maize grain typically makes up 25 percent of all cereal ingredients in the North Island. Therefore the total amount of maize grain that supports the New Zealand domestic pork industry is approximately 12,000 tonnes. The amount of maize grain used in the pork industry in 2008 is a similar quantity to what was used in the early 1980s. Hughes & Sheppard (1985) documented that 10,400 tonnes of maize grain was used by the pig industry in 1983.

4.1.3 Ruminant Feed

Ruminant feeds are the only other livestock feeds containing significant quantities of maize. Maize grain enters the ruminant feed sector as an ingredient in feed mixes and meals, it is also an ingredient in both calf meal and pellet mixes. The ruminant feed industry has grown significantly in recent years (Table 10). Most manufactured ruminant feeds enter the dairy industry, but small quantities are produced for sheep, deer and goat feeds. Three key companies supply the majority of the ruminant feed in New Zealand: NRM, Ingham Feeds and Nutrition and PCL Feeds. In 2008, the ruminant and calf feed sectors consumed 22.4 percent of all manufactured feed.

Table 10: Total quantity of manufactured feed entering the ruminant feed sector

	2004	2005	2006	2007	2008
Cow Feed	32,795	29,647	51,359	91,099	139,657
Calf Feed	53,124	51,866	58,353	68,028	67,938
Other	7809	5844	8189	2118	8719

Source: (NZFMA, 2006; NZFMA, 2007; NZFMA, 2008; NZFMA, 2009)

Ruminant feed often contains over ten sources of ingredients. A spokesman from the stock milling industry suggested that only 10 percent of all products are made up of maize grain. Other key energy sources include wheat, barley, copra, palm kernel meal, oats, sorghum and molasses. The inclusion of maize grain in these manufactured feeds depends on the price of maize in comparison to these substitute sources of energy.

Maize grain has to be cracked or rolled to be appropriate for ruminant consumption. An unknown proportion of maize grain is processed by larger farming operations and farmer owned milling co-operatives. These small processors are not always members of the NZFMA.

Within the dairy industry, compound feed is typically supplied to high input dairy systems abut is not a typical practice on most New Zealand dairy farms. There has, however, been an increase in the number of in-shed feeding systems on dairy farms, thus there is an increased demand for compound feed. The amount of compound feed consumed by the dairy industry increased rapidly over the last two seasons in response to a substantial increase in the milksolids payout. Usage of compound feed is expected to decline as the profitability of the dairy sector declines, due to a decrease in profits and competition from cheaper imported substitutes (Glassey & Clark, 2009).

Maize grain is an essential ingredient in at least one intensive beef finishing feedlot in New Zealand. The proportion of maize grain in the diet of the Wagyu beef cattle is steadily increased as the animal matures. This is said to increase the flavour of the finished product.

The total amount of maize grain used in ruminant feed in 2008 is estimated by industry sources to have been between 15,000 and 25,000 tonnes.

4.2 Food and Industrial Uses

4.2.1 Dry Processing

Processing and Quantities

There is one significant commercial dry milling operation in New Zealand that processes maize grain. The mill, based in Gisborne, produces a range of food ingredients purely from maize grain alone. The aim of the dry milling process is to isolate or recover the maximum amount of low fat, low fibre endosperm in large pieces free of the germ and pericarp. The production of a range of endosperm products is then carried out using roller mills, gravity tables, separators and purifiers (Chappell, 1985).

According to the milling company, the operation uses approximately 20,000 tonnes of maize grain per annum. From this, 10,000 tonnes of food products are produced plus 9,000 tonne of by-product. As the grain enters the mill, it passes through a screen which separates all the unwanted material from the maize grain. This includes stones, metal and plant material. Damaged or broken grain is also removed to prevent impurities entering the food production line. Approximately 1,000 tonne of the total quantity entering the mill is separated as screenings. The grain is then dampened quickly with hot water to soften the germ and the pericarp. The degermination mill then breaks open the kernel causing minimal damage to the germ. Once the kernel has been broken apart, the large flaky endosperm pieces are separated from the germ, and undergo further processing.

Manufactured and processed products

The products of maize dry milling include flaking grits, coarse, medium and fine grits, coarse or granulated meal called 'semolina', fine meal called 'polenta' and maize flour. Semolina is commonly used as an ingredient in snack food; however, it is also used in the brewing industry. Polenta can be cooked by itself as a dish similar to porridge. Flaking grits are used for the manufacture of the ready to eat breakfast cereal 'cornflakes'. Coarse grits and medium grits are used in the manufacture of cereal products and snack foods (Appendix F). Maize flour can be used as a complete substitute for wheat flour and is used in making breads, confectionary, and breakfast products. On average it takes 1.8kg of maize to produce 1kg of flour or grits.

The by-product from the milling operation, known as 'coarse hominey' is made up of the maize fractions left after the corn grits have been separated from the whole dried maize. This contains the bran, tip caps, germ and tailing streams. Hominey is an excellent source of carbohydrate and fibre, and is therefore suitable for use in a range of animal feeds and formulated foods. A complete nutritional analysis was obtained from the milling company (Table 11). This by-product is sold predominantly to dairy farmers, but a proportion is also sold as an ingredient for compound feed manufacture.

Approximately, 6400 tonnes is purchased directly by dairy farmers, while the remaining 1600 tonnes is manufactured into compound feed. The by-product feed contains carotene, a natural pigment, often valuable to egg producers. For this reason, it is commonly utilised in the poultry rations.

Table 11: Nutritional Analysis of by-products derived from industrial and food processing of maize

	ME MJ/kgDM	Crude Fibre (%)	Protein (%)	% Fat
Hominey	11.5-12.5	4.5-6.0	8-11	3.5-6.5

Relationships and supply chain management

The milling operation is owned and operated by one of New Zealand's leading maize seed companies. The operation has direct access to the services and products developed by the seed company, allowing for a tightly integrated supply chain structure. Contract growers are supplied with food grade maize seed, and receive agronomic services and expertise. The growers are contracted to supply high quality maize grain, which meets all quality specifications agreed to in the contract. The mill has people dedicated to ensuring that the grain purchased meets these high standards. The milling operation can then maintain a high degree of quality control over grain as it moves through the supply chain.

4.2.2 Wet Processing (Corn starch manufacture)

Processing and Quantities

The company, based in Auckland, is the only significant producer of starch and maize oil in the country. The process separates the key constituents of the maize kernel into their separate categories (Appendix G). The germ is removed and dried for oil extraction. Also the starch, fibre and gluten are separated, refined and stored (Chappell, 1985).

The Auckland plant mills "regular" maize varieties also known as yellow dent maize. The factory was originally a wheat starch factory, extracting gluten and making wheat starch and wheat glucose products. In the 1970's they built a maize plant, as the local cost structure of the wheat was too high. Starch can be manufactured from a number of cereal and root crops including maize, wheat, rice, sorghum, potatoes, tapioca and cassava. In Europe most starch production is from potatoes and in South-East Asia most is from tapioca. The United States and Brazil are very large maize growing and milling countries. Specific starches can be derived from maize grain that can not be derived from alternative feed types due its viscosity characteristics. Conversely, starch, which is used for paper or cardboard manufacture, can be equally derived from maize or other feed types such as tapioca. It is estimated up to 50,000 tonnes of maize grain is used annually by the wet milling company.

Higher quality specifications are required for maize grain entering industrial and food processing compared to maize grain grown for stock feed. Quality specifications relate to kernel size, the amount of broken grain, heat damage and insect damage.

Before milling, the maize is soaked in a solution rich in sulphur dioxide. This breaks the bonds between starch and protein and softens the maize for milling. The maize milling process then splits the maize grain into a number of raw components consisting of 70 percent starch, 16 percent fibre, 5 percent gluten, 3 percent oil and 4 percent corn steep liquor (CSL) based on dry weight. The nutrient-rich by-product, CSL, is used in stock feed.

Manufactured and processed products

The fibre and gluten is dried and sold as stock feed, the maize germ is crushed to extract the oil and germ fibre is returned to the main fibre stream. The slurry containing the starch is divided into three end use categories: unmodified starch, modified starches, and glucoses. Unmodified starch is dried and is simply processed into maize corn flour. A variety of chemically treated starches are produced for food and industrial application. The common forms of modified starches are ‘acid thinned’ starches, which are often used in confectionary. This manufacture process produces a starch with high ‘set back’ meaning the confectionary cools to a firm gel as seen in jelly beans. Another type of modification is an ‘oxidised’ starch, which is ideal for making white paper. There are two types of glucose derivatives commonly produced from maize starches. Firstly, ‘Acid Glucose’ is produced where hydrochloric acid is used to break the starch chain to produce glucose syrup. Secondly, 'enzyme glucose' is formed where specific enzymes selectively break the starch chain to produce specific sugar profiles (i.e. maltodextrins). The majority of glucose is used as sucrose sugar substitutes in products such as confectionary and ice-cream.

On average, 25 percent of the total maize grain used in wet processing ends up as by-product stock feed. The fibre by-product, sold under the name 'Avon Feed' or 'Avon Gold' (Table 12), enters the stock feed industry, most probably consumed by the dairy industry. In 2007, a total 4565 tonnes of the maize grain by-product was used in compound feed manufacture. Some of the gluten by-product is sold as ruminant feed, but most is used in the poultry industry. It is used as a supplement in layer diets as the gluten by-product possess yellowing characteristics, needed in layer diets to enhance the yellowness of the egg yolk. The oil extracted is refined, and is mostly used in margarine manufacture.

Table 12: Nutritional Analysis of by-products derived from industrial and food processing of maize

	ME MJ/kgDM	Crude Fibre (%)	Protein (%)	Fat (%)
AvonFeed	7.0-8.0	11.5	16.5-21.5	-

<u>Relationships and supply chain management</u>

The Auckland firm requires a year round supply of maize grain. From March through to June (harvest season) the firm will source 'undried' or 'wet' maize. As the grain is imbibed in water during the processing operation, the grain is not required to meet minimum moisture level standards. During the harvest season, maize is also dried by grain merchants and delivered throughout the year when it is required. The cost of domestically sourced grain increases as the year progresses due to the accumulating storage fees, thus maize is often imported at a lesser price. In a typical season, and if beneficial, a proportion of the maize will be imported, in order to bridge the deficit until the next harvest.

4.3 Industry Totals

There are six major end users of maize grain in New Zealand. Four of which are major livestock sectors. The remaining users are food and industrial processors. The total demand for maize grain by both the livestock feed industries and the food and industrial millers is equal to around 160,000 to 180,000 tonnes per annum. Livestock feed is the biggest market for maize grain in New Zealand, accounting for 52 percent of the maize grain utilised in 2008 (Table 13). This market can be divided up according to the most important feed types. The following livestock sectors are listed in order of highest usage of maize grain to least usage: layer feed, ruminant feed, broiler feed and pig feed. Total use of maize grain in livestock feed declined from 95,000 tonnes in 2007 to 80,000 tonnes in 2008, likely as cheaper alternatives were available (NZFMA, 2009). Food and industrial users utilise the remainder of the maize grain produced in New Zealand. In 2008, it is estimated these combined food industries utilised 42% of the country's 165,000 tonnes of maize grain.

Table 13: End users use of maize grain in 2008 (Constructed from pooled estimates)

	Low (t)	High (t)	Midpoint (t)
Livestock Feed			
Broiler	15,000	20,000	17,500
Layer	30,000	35,000	32,500
Pig	12,000	12,000	12,000
Ruminant	20,000	25,000	22,500
Unallocated	10,500	10,500	10,500
Food and Industrial			
Dry Processing	20,000	20,000	20,000
Wet Processing	50,000	50,000	50,000
Total	157,500	172,500	165,000

<u>Imports and Exports</u>

The proportions of imported maize grain for stock feed manufacture are very small. In 2005 and 2006 no maize was imported for compound feed manufacture in New Zealand. In 2007, 2,125 tonnes were imported (NZFMA, 2008). This equates to 2.3 percent of the maize grain used by the stock feed industry and less than 1 percent of the total feed imported. In, 2008 there were no grain imports listed by the NZFMA (Appendix H). Maize grain is, however, consistently imported by the cornstarch company in Auckland, New Zealand.

Up to 1000 tonnes are exported annually. There are established relationships between some island nations and several exporting firm. Further information was unable to be obtained.

4.4 Substitutes for Maize Grain

Alternatives to maize grain may be substituted within the livestock feed sectors, however, use of substitute products is limited in the food and corn starch processing industries. Depending on feed quality and price, maize grain may be substituted with other grains in livestock feed production if they are cheaper. According to specialists in the stock feed industry, the proportion of maize grain used in compound feed relative to other grains has gradually declined over the past 20 years. As the stock feed industry has grown, the demand for maize grain has failed to grow at the same rate. The statistics support views shared by feed industry representatives that suggest that in November 2008 maize grain is not as cost effective as alternative grains, particularly imported sorghum (NZFMA, 2009). The profitable inclusion of different grains is constantly monitored by stock feed companies as cost factors are continuously changing. The price of imported grain is strongly influenced by the exchange rate, shipping rates and availability. Recently, the amount of imported sorghum has rapidly increased, displacing use of other more expensive cereals (Table 14). In the past year, the amount of sorghum imported into New Zealand has increased by 140,000 tonne, while the amount of wheat and maize grain used has declined significantly; 100,000 tonne for wheat and 15,000 tonne for maize grain. Total grain use has remained relatively consistent. During this time, total grain use increased by 3.8 percent.

Table 14: Cereals used in stock feed manufacture for 2006-2008 (Appendix H)

	2006 (t)	2007 (t)	2008 (t)
Sorghum	35,000	27,000	166,790
Barley	124,500	123,000	131,104
Wheat	261,000	284,000	183,664
Maize	92,000	95,000	79,548
Total	517,000	540,000	561,106

Source: (NZFMA, 2007; NZFMA, 2008; NZFMA, 2009)

4.5 Costs and Returns

Total costs and prices have increased for maize grain crops in the last four years. The gross margin of maize grain crops in 2007/08 was above the long term average, due to a large increase in maize product prices (Table 15).

Table 15: Historical gross margin for maize grain grown in the Waikato region (MAF, 2008b)

Maize grain	2004/05	2005/06	2006/07	2007/08
Yield (t/ha)	10.5	11.0	10.5	10.0
Price ($/t)	270	275	295	365
Total costs ($/ha)	2126	2178	2385	2742
Gross Margin ($/ha)	709	847	712	908

The average costs for cropping and harvesting one hectare of maize grain for 2008/09 in the Waikato/Bay of Plenty region were collated from a number of sources (Appendix I). The sources included two companies involved in the sale of maize related products, revised forecast information from the MAF monitoring report 2008 (MAF, 2008b) and 'cost of production' (Appendix J) information collated from several maize contractors and obtained by FAR.

The harvest, cartage and drying costs combine to be 31 percent of the total grain costs. Fertiliser costs account for 40 percent of the total growing costs and 30 percent of the total costs. Other key expenditure items include cultivation and seed costs. The costing sheet excludes lease or interest costs on land. Current contract prices for grain range between $400 and $460 per tonne, so many growers stand to make margins up to and over $1000/ha. Since the time of planting the market price for maize grain has declined.

Profit is increased as the average yield increases (Table 16). The returns are dependent on both yield and price received. As maize grain yield increases the required price per tonne to breakeven decreases.

Table 16: Total costs and net profit at different yields based on costs for the 2008/09 season

Average yield and associated costs				
Wet Yield (t/ha)	11.0	12.1	13.3	14.5
Dry Yield (t/ha)	9.5	10.5	11.5	12.5
Growing & Harvest Costs/ha	$2,924	$2,924	$2,924	$2,924
Cartage/ha	$198	$219	$239	$260
Drying/ha	$440	$486	$532	$579
Total Cost/ha	$3,561	$3,628	$3,695	$3,763
Total Cost/tonne	$374	$346	$321	$301
$/tonne	**Gross margin ($/ha)**			
$300	-$711	-$478	-$245	-$13
$325	-$474	-$216	$42	$300
$350	-$236	$47	$330	$612
$375	$1	$309	$617	$925
$400	$239	$572	$905	$1,237
$425	$476	$834	$1,192	$1,550
$450	$714	$1,097	$1,480	$1,862

5. Maize Silage Industry

Whole crop maize silage is predominantly used in ruminant farming systems, primarily as a supplement to pasture.

5.1 Dairy

In New Zealand, the maize silage industry exists primarily to service the dairy industry. All growth in the maize silage industry can be attributed to the ongoing and increasing demand for supplementary feed by dairy farmers. Maize silage is a commonly used feed input on many of the country's dairy farms. Maize silage feeding is a strategic tool used by dairy farmers to maximise the profitability of their dairying systems. A Dexcel economic survey found that 26 percent of Waikato dairy farmers produced maize silage crops on their farms, and 36 percent brought maize silage in from elsewhere (Dexcel, 2004). Although this information is dated, it illustrates that both the cropping of maize silage and the purchasing of maize silage are important activities in the dairy industry.

5.1.1 Benefits

The three core benefits of maize silage supplementation are increased profit, increased environmental benefits, and reduced climatic risk. Used strategically, the on-farm benefits of maize silage feeding include: extended lactation through autumn feeding, increased body condition of dairy cattle at calving and increased pasture harvested per hectare. The improved reproductive performance and increased production per hectare often results in increased profit per hectare. Importantly, maize silage is used as a risk management tool to reduce the risk of unfavourable climatic variables effecting the production and performance of the farm system. It is easily stored on farm and can be used as required.

The use of maize silage as a source of feed on dairy farms has many benefits over pasture only dairy systems. Inputs of maize silage provide an opportunity for farmers to increase their stocking rate and production per hectare (Dalley *et al.,* 2005; MacDonald, 1999). The extra feed allows for a greater stocking rate to be carried and greater production per hectare to be obtained. Macdonald (1999) showed that a high maize input, high stocked Waikato dairy system produced 33 percent more milksolids per hectare than the control. Macdonald (1999) showed feeding maize silage also allows farmers to milk their herds longer in the season by increasing the average lactation length of the herd.

When fed in the spring, maize silage has a high substitution rate. This means that dairy cattle will consume less pasture to balance their intake of maize silage. Kolver *et al*. (2001) reported that pasture substitution can result in higher post-grazing herbage mass and subsequently higher pasture growth rates. For this reason it is used in the early spring when there is a clear requirement for pasture to be spared to avoid a large deficit later in the season.

Maize silage supplementation in autumn can be a tool used by farmers to maximise the live weight gain of dairy cows. Cows receiving starch based supplements, such as maize silage or concentrates in autumn, will gain more body condition than cows receiving pasture alone (Macdonald & Roche, 2004). Macdonald and Roche (2004) report that the average cow requires approximately 30 percent less maize silage than autumn pasture to gain 1 body condition score (BSC) unit (Table 17).

Table 17: Extra requirements above maintenance to gain 1 BCS for a dry cow (Macdonald & Roche, 2004)

Feed Type	MJ ME/kg DM	Jersey (kg DM)	Holstein-Friesian (kg DM)
Autumn Pasture	10.5	130	210
Pasture silage	10.5	140	220
Pasture silage	8.0	180	290
Maize silage	10.5	100	160
Grain	13.0	75	120

When fed alongside pasture, maize silage helps with the dilution of protein in the rumen, resulting in less protein excreted as urinary nitrogen. The readily available energy allows the rumen bacteria to utilise more of the protein in the pasture which is otherwise excreted in the urine (Ledgard *et al*., 2007). Maize silage cropping has also been recognised as a possible method that can be used on dairy farms to remove excess soil potassium built up by the application of dairy shed effluent (FAR, 2008b).

5.1.2 Processing and Storage

Processing and storage

Generally, a maize crop is harvested in early autumn when yields are maximised and the dry matter percentage is between 33 and 38 percent. However, it can be fed as a greenfeed crop in times of a severe feed shortage. In New Zealand, most of the silage is harvested using a forage harvester equipped with a plant processor. This processer cuts the plant 15cm above the ground and chops the plant into small pieces, a few centimetres long. This process disrupts the pericarp of the kernel and exposes the endosperm of the maize stalk, increasing its digestibility for later feeding (Densely *et al.,* 2004). The chop length is adjusted based on the moisture content of the crop. If the crop is excessively moist the chop length is increased, and decreases if the crop is deemed too dry. During storage, maize silage should be well compacted in order to prevent losses from aerobic respiration. Ruppel *et al.* (1995) found a relationship between low packing density and dry matter losses; measured losses for the poorly compacted silage were double that of the best compacted silage.

5.1.3 Production Systems

Production systems

The level at which maize silage is included in dairy farm systems varies depending on the type of system the farmer is operating. Dairy farm businesses can be classified along a continuum of five production systems depending on the level of imported feed bought into the system. The 'production system' classification allows farms in different regions to be compared on a comparable scale. Maize silage grown on-farm is not included as imported feed, but maize silage grown on a run-off block is included. In New Zealand dairy farms range from low input 'system 1' farms with less than 4 percent imported feed, to high input 'system 5' farms with over 30 percent of total feed imported. A dairy systems expert suggested that in 2006, approximately 50 percent of all farms were classified as production 'system 1' or 'system 2'. As at the end of 2008 this had now reduced to around 35-40 percent. The number of 'system 3' and 'system 4' farms had also increased slightly and the number of 'system 5' farms had increased from 5 to 10 percent. More feed is being sourced from off-farm.

Maize silage is an integral component of most high input systems, particularly in the North Island. For 'system 4' and 'system 5' farms, an inclusion rate of over 1000kg DM of maize silage per cow per year is common. Large users attempt to minimise losses of maize silage through storage and feeding out, with increased capital investment in infrastructure. Such infrastructure includes feeding and storage facilities. The level of maize silage used within a dairy farming system is typically determined by the stocking rate.

5.1.4 Distribution Channels

Distribution channels

Dairy farmers typically source maize silage through three different channels. It is either grown on-farm on the milking platform, grown on runoff area or it purchased from maize growers (traders). It is generally cheaper to grow and stack maize on-farm, however, the opportunity cost is that the paddock is out of pasture for up to nine months. Both cropping farmers and agricultural contractors share the market for tradable silage and play the role of maize silage growers. These growers are responsible for all growing costs of the crop, while the dairy farmers are responsible for all harvesting, cartage and stacking costs. The price of the maize silage is generally negotiated before the crop is planted. The price is valued on a dry weight basis (cents/kgDM). The total cost of bought-in maize silage will largely depend on the distance between the crop location and the dairy farm. There are advantages and disadvantages for on-farm sourced maize silage and off-farm sourced maize silage. The best option is often difficult to quantify as on-farm grown maize silage crops typically form part of a pasture renovation programme on dairy farms.

The results from the survey of agricultural contractors show there are regional differences in the proportion of maize silage planted by dairy farmers and by cropping farmers (Table 18). The majority of maize silage is planted on dairy land. In Canterbury, the majority of maize silage is planted by maize growers. The survey results show that the national breakdown is similar to that of the key maize silage regions of Waikato and Bay of Plenty. After the maize grown as part of the pasture renovation process is harvested, paddocks are re-grassed with perennial ryegrass cultivars. In continuously cropped maize crops, paddocks are generally sown with winter annual ryegrass or winter oats.

Table 18: Proportion of maize silage planting by land use in 2008 (results from the contractor survey)

	Non Traded (Dairy land)		Traded
	Platform	Run-off	Cropping
Waikato	40%	24%	36%
BOP	37%	26%	37%
Canterbury	11%	8%	81%
NZ	36%	24%	40%

5.2 Beef

Maize silage is a key feed source in at least one major beef finishing feedlot in New Zealand. The feedlot is highly reliant on maize silage as its principal source of feed. The successful growth of maize silage in the neighbouring regions of the feedlot was an important factor when determining the establishment of the feedlot. There are no comparative silages that are as cost effective as maize silage, thus the profitability of the operation heavily depends on the use of maize silage. The key feeding focus for the feedlot is to maximise carbohydrates and as maize silage is high in both starch and digestible fibre it is an ideal component in feed rations. When animals arrive at the feedlot the rations are generally high in roughage, a strategy used to reduce the risk of rumen acidosis. Generally, the proportion of maize silage in the diet decreases as the animals mature. Initially maize silage contributes up to 40 percent of the diet. The proportion is steadily reduced as the feeding programme shifts towards a greater energy proportioned diet. This is done to increase the marbling of the meat. The typical diet requires a crude protein proportion of 12-13 percent. This protein demand is met by protein in wheat, barley and urea. Alongside maize silage, other forms of carbohydrates used include tapioca, barley, and wheat. Depending on crop yields, the feedlot uses up to 7,200tDM per year.

5.3 Substitutes for Maize Silage

Alongside pasture, maize silage is the most commonly used supplementary feed in the New Zealand dairy industry. However, in recent years there has been increasing competition from imported products. The amount of Palm Kernel Extract (PKE) (a by-product from the palm oil industry) imported into the country has increased significantly from 100,000 tonne in 2004 to over 1,100,000 tonne in 2008 (Figure 7). Although the two products are not nutritionally identical, PKE competes against maize silage. The metabolisable energy of PKE is similar to that of maize silage. It is significantly lower in starch but higher in fibre. As a product it has many advantages over maize silage. Firstly, it is readily available. Unlike maize silage, it can be delivered year round, with little forward planning needed. Secondly, it can be easily fed-out through in-shed feeding systems. PKE is an unpalatable feed and is self-limiting at feeding rates over 3kg. Industry specialists agree that maize silage is the more superior product but at current market rates PKE is the more profitable product. As at January 2008, PKE is a cheaper form of energy at 2.1 cents per megajoule of metabolisable energy (MJME) in comparison with maize silage which currently can be up to 3.0 cents per MJME. This was based on a price of PKE at \$200/tonne and a price of maize silage of \$0.30/kgDM.

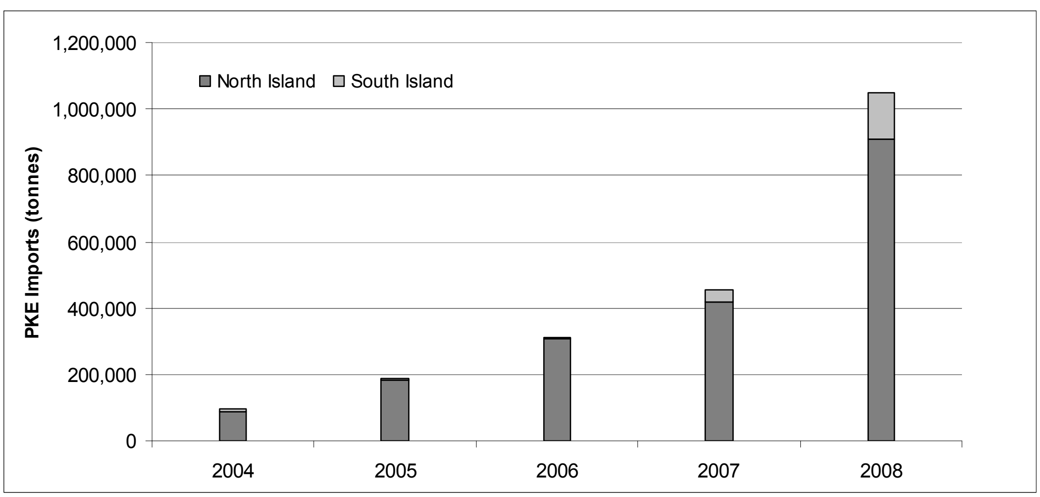

Figure 7: Total imports of Palm kernel extract (PKE) into New Zealand 2004-2008 (Source: NZFMA)

5.4 Costs and Returns

The gross margin of maize silage crops in 2007/08 was above the long term average, due to a large increase in maize product prices. In particular, price increases in dairy commodities led to a greater demand for maize silage. Consequently the total area of maize grown increased by 20 – 25 percent in 2007/08 (MAF, 2008b). The gross margins for maize grain and maize silage usually differ (Table 15; Table 19). Maize silage is typically more profitable than maize grain. Maize silage is, however, a more depletive crop than maize grain, because in maize grain crops, potassium and other nutrients are reverted into the soil through the stubble.

Table 19: Historical gross margin for maize silage grown in the Waikato region (MAF, 2008b)

Maize silage	2004/05	2005/06	2006/07	2007/08
Yield (kgDM/ha)	18500	21000	19500	17500
Price ($/kgDM) "in the stack"	0.21	0.22	0.24	0.29
Total costs ($/ha)	3157	3288	3405	3905
Gross Margin ($/ha)	768	1297	1205	1215

The estimated average costs for cropping and harvesting one hectare of maize silage in the Waikato/Bay of Plenty region for 2008/09 were collated from a number of sources (Appendix K). The sources included two companies based in product sales, estimates from the MAF monitoring report 2008 (MAF, 2008b) and cost of production information obtained by FAR. The total costs of maize silage are made up of two key areas of expense; growing costs and harvest costs (including harvesting, stacking, covering and inoculants). Growing costs account for two thirds of the total costs. Total fertiliser costs account for nearly 30 percent of the total cost of maize silage. The other core expenses include cultivation, seed and harvesting which account for 36 percent of total costs. The costing sheet does not include cartage as this amount varies depending of carting distance. Two sources suggest the average cartage costs are $558 per hectare increasing the total expenses per hectare by 14 percent.

The returns from maize silage differ between on-farm grown maize and maize grown for sale. Maize growers receive a price based on 'standing silage' and are only responsible for the growing costs. Returns generated by on-farm grown maize silage are received from the on-farm benefits of supplementary feeding e.g. milk production and are often difficult to quantify. In both cases, yield is the major factor determining the level of return received. The average growing cost of maize silage is $2,800/ha, thus profits will be made at saleable yields over 17,000kgDM/ha and at prices above $0.18/kgDM (Table 20). However, many maize growers have leased land at rates up to and over $1000/ha. The standing silage price must then be $0.23/kgDM or above at yields over 17,000kgDM for such growers to break even. Market rates for standing silage have declined from prices as high as $0.30/kgDM at the start of the 2008/09 season to prices as low as $0.20/kgDM as at February 2009.

Table 20: Gross Margin for traded maize silage for the 2008/09 season given growing costs of $2700/ha

	Yield (saleable kgDM/ha)						
Standing price	17,000	18,000	19,000	20,000	21,000	22,000	23,000
0.16	-$88	$72	$232	$392	$552	$712	$872
0.18	$252	$432	$612	$792	$972	$1,152	$1,332
0.20	$592	$792	$992	$1,192	$1,392	$1,592	$1,792
0.22	$932	$1,152	$1,372	$1,592	$1,812	$2,032	$2,252
0.24	$1,272	$1,512	$1,752	$1,992	$2,232	$2,472	$2,712
0.26	$1,612	$1,872	$2,132	$2,392	$2,652	$2,912	$3,172

6. Discussion and Conclusions

6.1 Review of methodology

No research is without its limitations. Patton (1990, p.162) noted that "there are no perfect research designs, there are always tradeoffs." The selected research approach was the most suitable option given the time and funding allocations for this project. The case study approach proved to be an informative method and most of the intended information was collected. Problems occurred when sensitive information could not be obtained from case studies. This occurred when the required information was deemed commercially sensitive.

An alternative method for gathering maize area through satellite imagery was investigated. It is possible to obtain an exact measure of the total land area in maize production through the analysis of satellite photographs. This method was rejected based on the time necessary to correlate and analysis the images. Up to date images would have had to be taken at a stage when the all crops are identifiable. As remote sensing technology and digital imagery becomes more available and cheaper in the future, it is likely the accuracy of such a study can be significantly increased.

6.2 Price Volatility

The price of both maize grain and maize silage are extremely volatile from year to year. The market environment is strongly influenced by both grain and dairy commodity prices. In the 2007/08 season, a favourable dairy payout increased the demand for maize silage throughout most of the country. Although the drought increased the price of non-contracted silage, the use of maize silage within the dairy industry was profitable at market rates. The 2008/09 season has been extremely volatile with high prices set at the start of the season falling both in maize silage and maize grain. The MAF arable monitoring report (October 2008) used prices of $0.40/kgDM "in the stack" for maize silage, and $475 per tonne for maize grain as forecast prices for the 2008/09 season. The large increase in maize production particularly maize silage was encouraged by the dairy payout forecast. Since the time of planting, international commodity prices for both maize grain and dairy products have fallen significantly. Nearly all industry specialists interviewed throughout November suggested there would be a large over supply of both maize grain and maize silage at harvesting and this will drive down the market price. As at February 2009, the market price for standing silage was between $0.20-0.22/kgDM, a price below what is required to cover all growing costs.

The price of maize silage is dictated by supply and demand, with demand primarily fuelled by the forecasted dairy payout. This section has noted that the price of tradable maize silage can be extremely volatile, thus tending to favour one of the two parties involved in the contract. A reform to a margin based contract where the return is linked to both the dairy payout and cost of production may reduce the risk to both parties in the future.

6.3 Supplementary feed usage on dairy farms

Although the recent growth in the maize industry experienced in the 2007/08 and 2008/09 seasons has been fuelled by exceptional dairy payouts, the maize silage industry has experienced increasing growth since the early 1990s. To some extent the growth in the maize industry has supported the intensification of dairying over this time. Throughout the interview process with dairy sector representatives, it was evident different viewpoints existed in regards to the intensification of the dairy industry. Maize was viewed by all as an important feed source to the dairy industry, but future growth of the maize silage industry was said to depend on its profitable inclusion into dairying systems. The cost of land was said to be a driver increasing the need for dairy farmers to intensify. However, historically there has not been a relationship linking the total feed purchased and the operational profit when businesses against are matched against each other (Dexcel, 2004) (Appendix L). The dairy industry's research body, DairyNZ, suggests that dairy farmers should pay no more than 5% of the payout for supplementary feed (DairyNZ, 2008). At the 2008/09 Fonterra forecast payout of $5.10/kgMS, this would equate to a supplement price of $0.255/kgDM. However, a large amount of dairy farmers are contracted to purchase supplement at prices exceeding $0.30/kgDM.

6.4 Economic Contribution

The total value of product produced from the maize industry has been calculated using the estimated area of maize in production and the estimated average price of each product. The researcher used best estimate figures of 72,000ha of maize silage and 20,000 ha of maize grain. Given price assumptions of \$0.30/kgDM 'in the stack' and \$400/tonne of maize grain, the value of products produced in the maize industry add to \$490 million dollars. A sensitivity analysis was constructed to demonstrate the possible value of the industry using high and low product prices and production quantities (Appendix M). The low range assumed prices of \$0.26/kgDM for maize silage 'in the stack' and 160,000 tonne of maize grain at \$325/t. The high range assumed prices of \$0.36/kgDM maize silage 'in the stack' and 220,000 tonne of maize grain at \$450. Using the sensitivity, the total industry value ranged from \$408 million to \$670 million,

6.5 Conclusions

This study highlighted a number of key industry dynamics or factors that operate within the New Zealand maize industry. The most important discussion points are addressed in this section.

The maize industry has shown exceptional growth in the last 15 years (Appendix N). This can be attributed to a growing demand for maize silage by the dairy industry. The research estimates that the maize silage industry has grown from approximately 3,000 hectares in 1994/95 to a probable area of 72,000 hectares in 2008/09 (Appendix N). During this time the level of maize grain production has fluctuated between 150,000 tonnes and 200,000 tonnes. In the 2007/08 and 2008/09 seasons industry specialists suggest the industry growth was over 20% each season.

This dissertation has highlighted that discrepancies exists in respect to industry statistics. There was a large range in the information gathered in respect to industry area and industry production. The key source of reference data obtained from FAR did not align with other information sources. The FAR information seemed to understate the size of the market. This dissertation reports that the size of the maize industry may be larger than the FAR levy accounts for, thus there may be a substantial amount of money owed to FAR. As a range of values were obtained for the size of the industry, there is considerable doubt that the FAR levy-derived area is the most reliable source of information. The researcher was unable to cross reference the area obtained by using the FAR levy data, with information on maize seed sales, as this information is not publicly available. As one seed company dominates the maize seed market, they are unable to make their information public as it would roughly indicate the size of their market share.

The use of maize grain in livestock feed production is dependent on its price relative to other cereals. Barley, wheat, sorghum, and maize grain are typically interchangeable ingredients within most livestock diets. This is evident with the use of maize grain in North Island mills, and not in South Island mills. In certain circumstances, maize grain is favoured over other products, for example, in layer feed because of its level of carotene. Like most commodities, the prices of cereal grains are influenced by the supply and demand of the products domestically and internationally and imported grains are often cheaper than domestically sourced grains.

The demand for maize grain by food and industrial processers is less flexible than livestock feed manufacturers. A range of corn products are produced throughout the dry process ranging in size from flaking grits to maize flour. These products can only be processed from maize grain. Therefore there are no substitutes for maize grain for dry milling companies. However, there is a range of food sources that can be used for starch manufacture but this requires an increase in capital infrastructure investment, including processing facilities. Also, there are specific food applications that particularly suit maize grain due to its viscosity characteristics.

The dairy industry's demand for maize silage is very dependent on a number of key influencing factors. The rate at which it is profitable to include maize silage within a dairy system is dependent on the dairy payout. The cost of alternative substitutes also affects the demand for maize silage. Future growth in the maize silage market will depend on the profitability of the inclusion of maize silage in dairy farming systems.

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Appendix A

INTERVIEW GUIDE

Pork Industry Representatives

- Is maize a commonly used feed in the Pork and Poultry Industry?
- How is maize grain commonly sourced? Is maize grain generally grown under contract for the pork and poultry farmers?
- Who are the major consumers of maize in the Pork and Poultry sector?
- What are the key drivers for using maize as a source of feed?
- Explain how sensitive the use of maize is to price and other factors and how does that effect the use of maize?
- Substitutability

Stock Feed Industry/Merchants

- Do you purchase maize silage and or maize grain? From where do you source your raw maize ingredients for your stock feed operation?
- Do enter in contracts with growers to ensure quality and quantity of maize?
- How many tonnes or do purchase for your stock feed operation?
- Who are your major competitors?
- What are the key drivers for using maize as a source of feed?
- Explain how sensitive the use of maize is to price? How does that effect the selection of maize the major feed used?
- Price relative to substitute products?

Beef Industry Representatives

- What quantity of maize silage/grain is grown for the feedlot?
- Why is maize silage/grain used as a source of feed as apposed to alternatives?
- Explain how reliant the feedlot operation is in regards to the use of maize?
- What are the key drivers for using maize as a source of feed?

- Explain how sensitive the use of maize is to price? How does that effect the selection of maize the major feed used?

Dairy Industry Representatives

- How does maize fit into each of the five production systems defined by the industry?
- How many farms fit into the different systems? What are the general trends of maize use? Has maize used increased? Why has maize use increased?
- Why is maize silage/grain used as a source of feed as apposed to alternatives?
- What are the typically quantities of fertiliser used?
- How much maize grain is fed in the dairy industry?
- What are the key drivers for using maize as a source of feed?
- Explain how sensitive the use of maize is to price? How does that effect the selection of maize the major feed used?
- Substitutability

Note: These above questions were used only as an interview guide. More detailed, secondary questions were developed during the interview to search and probe further into the relevant issues pertaining to each case study interviewee.

Appendix B

MAIZE CONTRACTORS SURVEY

Mr. J Booker
PO Box 84
Lincoln University
Canterbury
8150

Date

Contractors Address

RE: Research Questions

Dear Contractor

Please find below the following research questions that of importance to my research study.

- What is your split between silage and grain?
- What has been the increase of maize planted for silage in 2008?
- Do you think this percentage increase is typically of your region?
- What has been the increase in maize planted for grain in 2008?
- Do you think this percentage increase is typically of your region?
- What proportion of maize silage is planted on dairy farms?
- What proportion of maize silage is planted on dairy support land (run-off)?
- What proportion is planted as trading silage e.g on lease land, or cropping land?
- What proportion of total planting area would be continuously cropped as apposed to out of long term pasture?

Regards,
James Booker

Mob: 0272545808
Email: bookerj@lincoln.ac.nz

Appendix C

NEW ZEALAND MAIZE GRAIN AREA & PRODUCTION STATISTICS 1960-2006

(FAOSTAT, 2008)

	Area (ha)	tonne	average yield
1960	2655	10262	3.9
1961	2954	13843	4.7
1962	3196	15470	4.8
1963	3905	18898	4.8
1964	3925	23546	6.0
1965	3265	19356	5.9
1966	3061	18492	6.0
1967	5873	35892	6.1
1968	7138	51158	7.2
1969	8089	58624	7.2
1970	11982	101178	8.4
1971	14806	116226	7.8
1972	12858	117507	9.1
1973	12516	88304	7.1
1974	20558	157599	7.7
1975	26028	184469	7.1
1976	28566	210419	7.4
1977	24761	174536	7.0
1978	22287	178998	8.0
1979	19374	156461	8.1
1980	17224	152080	8.8
1981	18750	170071	9.1
1982	17204	142768	8.3
1983	17576	154324	8.8
1984	17823	174604	9.8
1985	19507	187700	9.6
1986	18967	176134	9.3
1987	16016	136944	8.6
1988	14859	138694	9.3
1989	17556	161651	9.2
1990	19046	183388	9.6
1991	17966	163842	9.1
1992	15925	133100	8.4
1993	14700	142800	9.7
1994	16505	160797	9.7
1995	18559	209700	11.3
1996	19500	194000	9.9
1997	17500	176000	10.1
1998	19446	197000	10.1
1999	17700	181000	10.2
2000	17000	176800	10.4
2001	14178	148847	10.5
2002	18291	197182	10.8

2003	15000	168000	11.2
2004	19235	210253	10.9
2005	20461	227054	11.1
2006	17030	182836	10.7

Appendix D

FAR LEVY CALCULATIONS

Results from 2007/08 Maize levy collection			
	Maize Silage	Maize Grain	Assumptions
Seeds/Unit	10000	10000	
Seeds/bag	80000	80000	
Levy/unit	0.9	0.9	
Average Planting Rate (seeds/ha)	108,000	80,000	<-- Industry averages
Average bags/hectare	1.35	1.0	<-- Average planting rate/seeds p/bg
Average Units/ha	10.8	8	<-- average planting rate/10000
Levy/ha	$9.72	$7.20	<-- 0.90 * average units per ha
Income received from levy	$499,494		<-- Derived from FAR accounts
Estimated Area for 2007 planting	unknown	17,700	<-- Average area in production
Estimated Revenue - Maize grain		$127,440	<-- $7.20 * 17700 hectares
Estimated Revenue - Maize Silage	$372,054		<-- $499,494 - $127,440
Area obtained from revenue	38277		<-- $372,054/9.72
Summary of Results	**Silage**	**Grain**	**Total**
Total Units Collected (10K units)	**554993**		
Total revenue	**$499,494**		
Average Planting Popn	**108000**	**80000**	
Levy/ha	**$9.72**	**$8.10**	
Area Planted (hectares)	**38,277**	**17,700**	**55,977**

Appendix E

LIVESTOCK FEED USAGE OF COMPOUND FEED

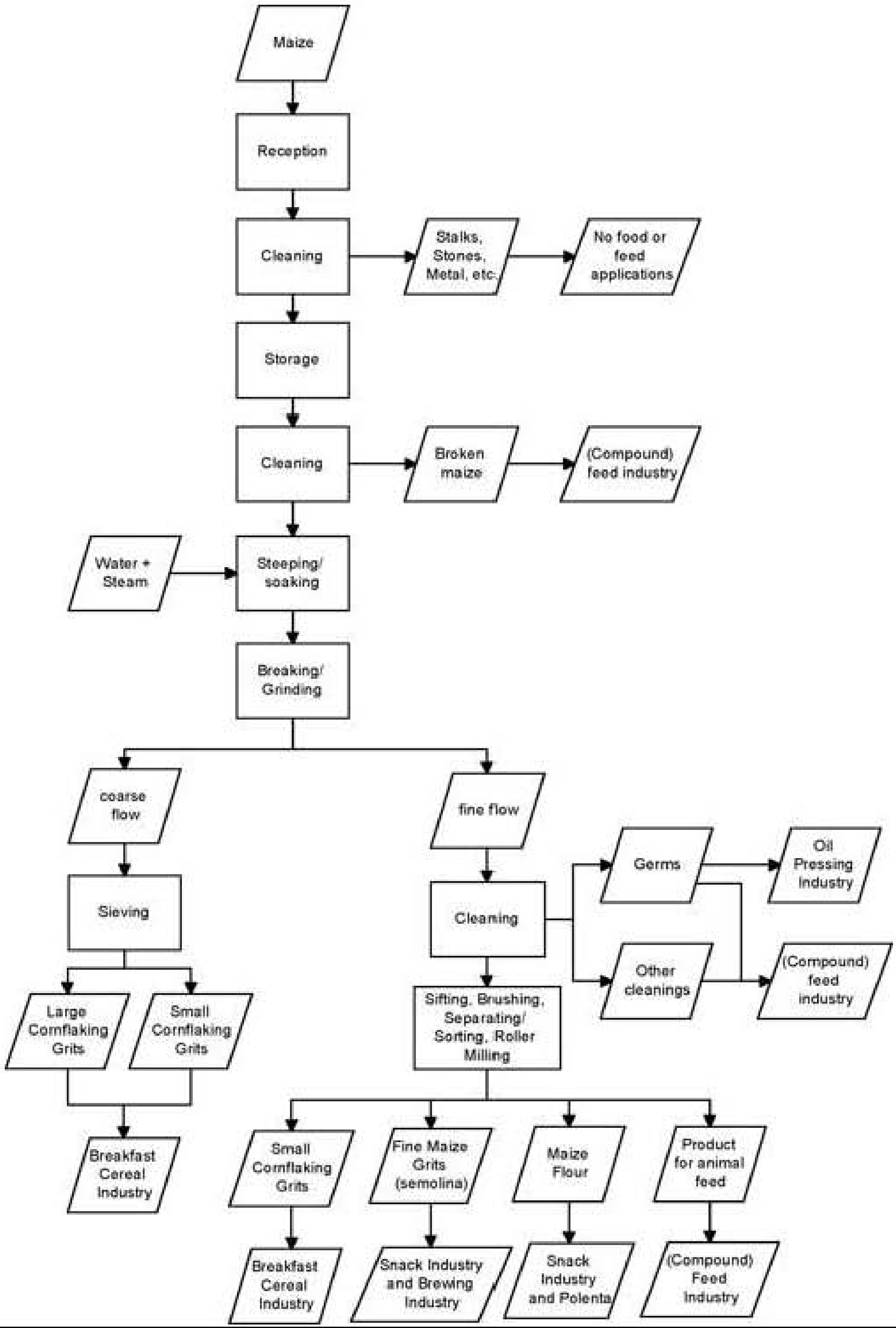
SECTOR USAGE OF COMPOUND FEED PRODUCTION 2005 - 2008 (NZFMA, 2006; NZFMA, 2007)					
	Year ending 31st December				
	2004	2005	2006	2007	2008
Poultry					
Growers	344390	357940	343864	336427	349061
Breeders	46795	43290	45666	45624	52410
Layers	132779	126118	112776	117166	127162
		527348	502306	499217	528633
Pig					
Grower	160311	160311	144144	144144	142033
Breeder	54871	54871	43056	43056	40061
Calf					
Milk replacers	3335	5107	4831	5360	4811
Meals, Pellets	41460	38775	45300	55890	54499
Textured Feeds	8329	7984	8222	6778	8628
					67938
Ruminant					
Dairy	32795	29647	51359	91099	139657
Beef, Sheep, Deer, Goat	7809	5844	8198	2118	8719
		35491	59557	93217	148376
Horse					
Meals, pallets, crumbles etc	1876	2145	1729	3697	5969
Textured Feeds	5880	5335	6771	5261	8210
Others					
Aquaculture			2	9	2
Dog	2612	4832	2977	2316	4739
Rabbits, Small Animals	1137	1331	968	1122	1002

Emu/Ostrich	399	529	999	328	111
Others	894	1310	357	1126	709
Raw Materials					
Grain & Grain Mixtures	3849	4334	7665	6333	15297
All Other Raw Materials	675	766	521	1877	2341
Unblended Milk Powers foe Sale	20	60	20	190	45

TOTAL BULK		**755420**	724315	767006	837056
North Island		**509227**	484687	519508	570250
South Island		**246193**	239628	247498	266806
TOTAL BAGGED		**95109**	105109	110015	128410
North Island		**71777**	77635	83928	91034
South Island		**23332**	27474	26087	37376
TOTAL PER ISLAND	**850216**	**850529**	**829424**	**877021**	**965465**
North Island		**581004**	562322	603436	304181
South Island		**269525**	267102	273585	661284

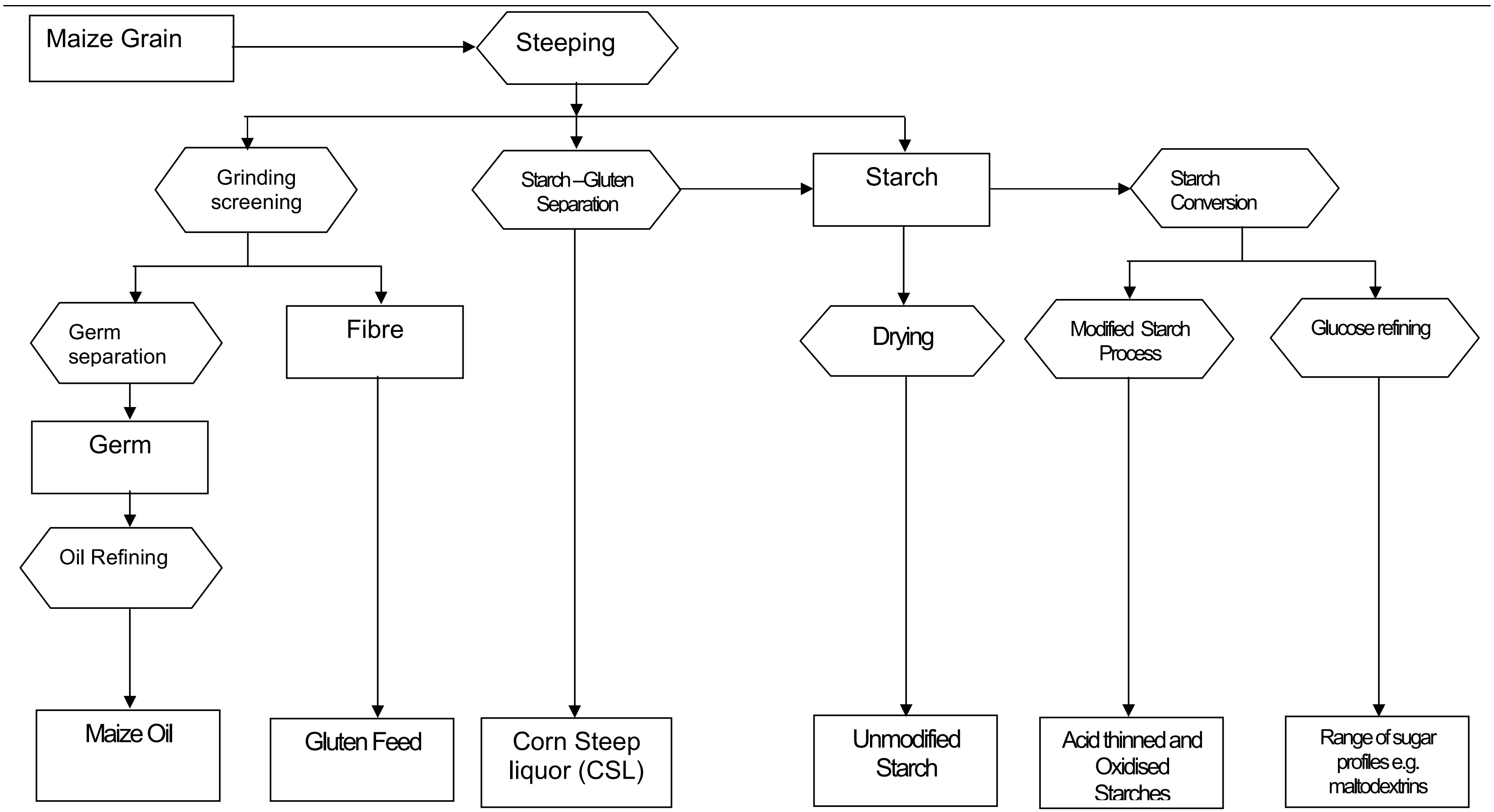
Appendix F

DRY PROCESSING PROCESS



Appendix G

WET MILLING PROCESS



Appendix H

SOURCES AND TYPES OF RAW MATERIALS USED IN COMPOUND FEED PRODUCTION 2005 & 2006

		2005			2006		
		Domestic	Imported	Total	Domestic	Imported	2006
Grains		T	T	Tonnage	T	T	Tonnage
Wheat		141787	131357	273144	139405	121486	260891
Barley		101110	9599	110709	94215	30329	124544
Oats		665	0	665	715	0	715
Maize		116231	0	116231	92046	0	92046
Sorghum		0	44430	44430		34672	34672
Triticale		1541	0	1541	1273	0	1273
Others		370	6	376	1517	1153	2670
Grain-by-products							
Wheat (Bran, pollard and broll)		52396	0	52396	53909	0	53909
Barley (Malt culms, brewers grain)		96	0	96	32	0	32
Maize (Avon feed, Avon gold)		4524	0	4524	3070	0	3070
Others (bread, biscuits)		554	0	554	2365	0	2365
Animal Proteins							
Meat and bone meal (non poultry)		59839	559	59836	52685	0	52685
Blood meal (non poultry)		6894	0	6894	5628	0	5628
Fishmeal		123	3857	4539	712	3427	4139
Poultry by-product meal		2435	0	2435	3290	0	3290
Milk powders		5369	247	5616	2745	322	3067
Others		3598	260	3858	4862	215	5077
Plant Proteins							
Peas		1979	0	1979	4951	0	4951
Soya Meal		0	91874	91874	0	92056	92056
Copra		0	3328	3328	0	5137	5137
Palm Kernel		0	11918	11918	0	13702	13702
Others		1631	2371	4002	3950	6010	9960
Others							
Limestone					12278	329	12607
All other raw materials		40811	1435	49055	37477	1555	40514
TOTAL DOMESTIC		**541953**			**517125**		
TOTAL IMPORTED			**301241**			**310393**	
TOTAL FEED USED				**850000**			**829000**

(NZFMA, 2006; NZFMA, 2007)

Appendix H

SOURCES AND TYPES OF RAW MATERIALS USED IN COMPOUND FEED PRODUCTION 2007 & 2008

(NZFMA, 2008; NZFMA, 2009)	2007			2008		
	Domestic	Imported	Total	Domestic	Imported	Total
Grains	T	T	Tonnage			
Wheat	152240	132551	284791	176854	6810	183664
Barley	122009	827	122836	131104	0	131104
Oats	553	0	553	2096	0	2096
Maize	92757	2125	94882	79548	0	79548
Sorghum	0	27416	27416	0	166790	166790
Triticale	1795	0	1795	1184	430	1614
Others	1792	5629	7421	0	13443	13450
Grain-by-products						
Wheat (Bran, pollard and broll)	51474		51474	46770	2771	49541
Barley (Malt culms and brewers grain)	38	0	38	156	0	156
Maize (Avon feed, Avon gold)	4565	0	4565	6489	23	6512
Others (bread, biscuits)	1211	0	1211	1121	1778	2899
Animal Proteins						
Meat and bone meal (non poultry)	52892	0	52892	50858	0	50858
Blood meal (non poultry)	5967	0	5967	6442	0	6442
Fishmeal	72	3073	3145	77	3550	3626
Poultry by-product meal	2520	0	2520	2770	0	2770
Milk powders	4946	358	5304	5943	330	6274
Others	2587	156	2743	92	0	92
Plant Proteins						
Peas	4236	0	4236	2130	0	2130
Soya Meal	0	101863	101863	0	108225	108225
Copra	0	6264	6264	0	9133	9133
Palm Kernel	0	23727	23727	0	33086	33086
Others	1687	4825	6512	673	20554	21227
Others						
Limestone	16401	873	17274	20079	1581	21660
All other raw materials	40905	1898	47571	36141	8953	62103
TOTAL DOMESTIC	**560647**			**570527**		
TOTAL IMPORTED		**311585**			**377457**	
TOTAL FEED USED			**877000**			**9 65000**

Appendix I

TOTAL MAIZE GRAIN COSTS FOR 2008/09

Maize grain production costs for the Waikato/Bay of Plenty region 2008/09 season

Costs ($/ha)	**#1**	**#2**	**#3**	**#4**	**Average**
Gylphosate	100	90	93	76	*90*
Cultivation	400	360	350	360	*368*
Lime	80	60	40	70	*63*
Base Fertiliser	250	250	206	235	*235*
Planting	140	135	135	144	*139*
Seed	455	465	472	464	*464*
Starter Fertiliser	450	450	353	450	*426*
Pre-emergent herbicide + application	150	80	152	134	*129*
Post-emergent herbicide + application	60	60	60	60	*60*
Side Dressing + Application	400	350	366	350	*367*
Other	10	15	15	18	*15*
Interest (8 months)	235	220	130	190	*194*
Total growing costs	**2,730**	**2,535**	**2,372**	**2,551**	***2,547***
Harvest: Combine 11.5t	380	380	402	345	*377*
Drying (24%-14%)	555	555	495	467	*518*
Cartage (50km)	249	250	220	216	*234*
Total harvest costs	**1,184**	**1,185**	**1,117**	**1,028**	***1,129***
Total costs	**3,914**	**3,720**	**3,489**	**3,579**	***3,695***

Source: (1) product sales company (2) product sales company (3) MAF (4) FAR

Appendix J

STANDARD PRICES FOR MAIZE CROPPING ACTIVITIES (Source: FAR)

Standard Prices - North Island Maize ($/ha)		
	2007-08	2008-09
Discing	160	190
Ploughing	170	200
Power harrow	130	160
Regrass	230	250
Side-dress	70	80
Sowing	120	140
Spraying	35	40
Bulk Spreading	35	40
Ripping	120	120
Mulching	50	50
Harvest Silage	500	600
Harvest Grain	300	
Helicopter fert	90	100
Standard Prices - South Island ($/ha)		
	2007-08	2008-09
Disc	55	55
Disc & Roll	65	70
Disc Roller	55	55
Grub	30	30
Grub & Roll	35	35
Grub & Harrow	35	40
Harrow	20	20
Harrow & Roll	30	30
Maxitill	35	35
Maxitill & Roll	40	40
Mulch	50	50
Plough	75	75
Plough & Press	90	90
Press	25	25
Powerharrow	75	75
Powerharrow & Roll	80	80
Rip	50	50
Roll & Harrow	30	30
Subsoil	50	50
Tyne	35	35
Contract Spray	35	35
Own Spray	15	15
Cambridge Roll	25	25
Heavy Roll	30	30
Roll	25	25

Appendix K

TOTAL MAIZE SILAGE COSTS FOR 2008/09

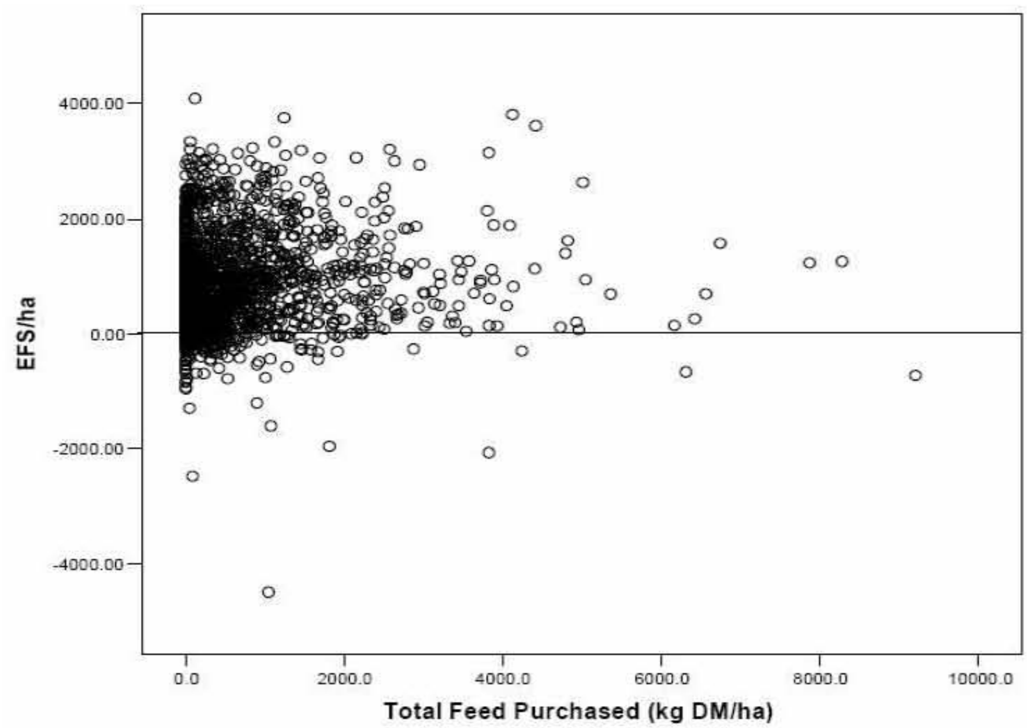
Maize silage production costs for the Waikato/Bay of Plenty region 2008/09 season

Costs ($/ha)	**(a)**	**(b)**	**(c)**	**(d)**	**Average**
Gylphosate	100	81	76	93	*88*
Cultivation (Plough & Power harrow)	400	320	360	350	*358*
Lime	80	128	92	120	*105*
Base Fertiliser	500	562	476	462	*500*
Starter Fertiliser	450	421	450	400	*430*
Seed Treated	522	574	574	503	*543*
Pre-emergent herbicide + application	150	140	134	152	*144*
Planting	140	135	144	135	*139*
Side Dressing + Application	400	240	260	366	*317*
Interest (8 months)	255	220	139	127	*185*
Total Growing Costs	**2,997**	**2,821**	**2,705**	**2,708**	*2,808*
Harvesting		603	603	625	*610*
Inoculants		244	258	280	*261*
Stacking/Rolling/Covering		413	400	420	*411*
Total Harvest & Stacking Costs		1,260	1,261	1,325	*1,282*
Total Costs		**4,081**	**3,966**	**4,033**	***4,027***

Source: (a) product sales company (b) product sales company (c) FAR (d) MAF

Appendix L

TOTAL SUPPLEMENT IN RELATION TO TOTAL OPERATIONAL PROFIT (EFS/HA) (Dexcel, 2004)



Appendix M

VALUE OF THE MAIZE INDUSTRY

Source: Researcher used information gathered throughout research process as base assumptions in the sensitivity analysis

	Price per kgDM 'in the stack'					
Average Production*	**0.26**	**0.28**	**0.30**	**0.32**	**0.34**	**0.36**
19tDM/ha	356	383	410	438	465	492
20tDM/ha	374	403	432	461	490	518
21tDM/ha	393	423	454	484	514	544
22tDM/ha	412	444	475	507	539	570

* Using 72,000ha

	Price/tonne ($/t)					
Total Production	**$325**	**$350**	**$ 375**	**$400**	**$ 425**	**$450**
160,000	52	56	60	64	68	72
180,000	58.5	63	67.5	72	76.5	81
200,000	65	70	75	80	85	90
220,000	71.5	77	82.5	88	93.5	99

TOTAL VALUE OF MAIZE INDUSTRY (MILLION)(SILAGE + GRAIN REVENUE)

Increasing Product Price

Increasing Production Quantity						
	408	439	470	502	533	564
	433	466	500	533	566	599
	458	493	529	564	599	634
	483	521	558	595	632	669

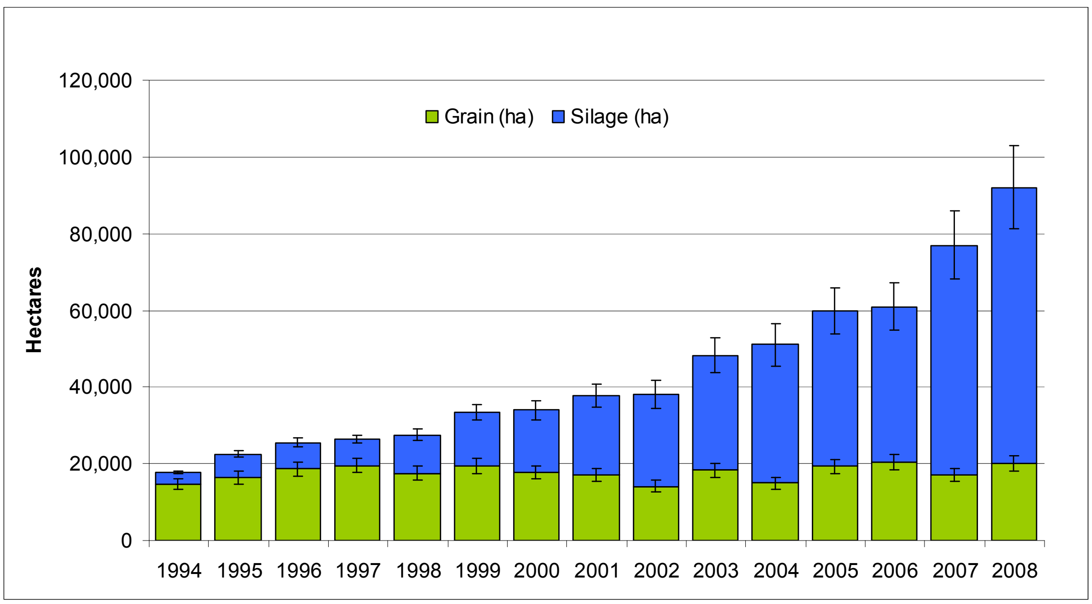
Possible range: 408 to 669 million

Appendix N

NEW ZEALAND MAIZE SILAGE AND MAIZE GRAIN AREA STATISTICS 94-08

Source: Researcher used information gathered throughout research process as base information. The information below is a best estimate only.

(Pooled estimates)			
Year	**Maize Silage (ha)**	**Maize Grain (ha)**	**Total (ha)**
1994	3000	14700	17700
1995	6000	16505	22505
1996	7000	18559	25559
1997	7000	19500	26500
1998	10000	17500	27500
1999	14000	19446	33446
2000	16240	17700	33940
2001	20787	17000	37787
2002	24000	14178	38178
2003	30000	18291	48291
2004	36000	15000	51000
2005	40500	19235	59735
2006	40500	20461	60961
2007	60000	17030	77030
2008	**72000**	**20000**	**92000**



Growth in the maize silage industry from 1994-2008 (results from pooled estimates)